

formerly AVIATION AGE

CONOVER-MAST PUBLICATION

# *space aeronautics*

RESEARCH • DESIGN • DEVELOPMENT

*aircraft / missiles / spacecraft*



PROPERTY OF  
CHICAGO MIDWAY LABORATORIES

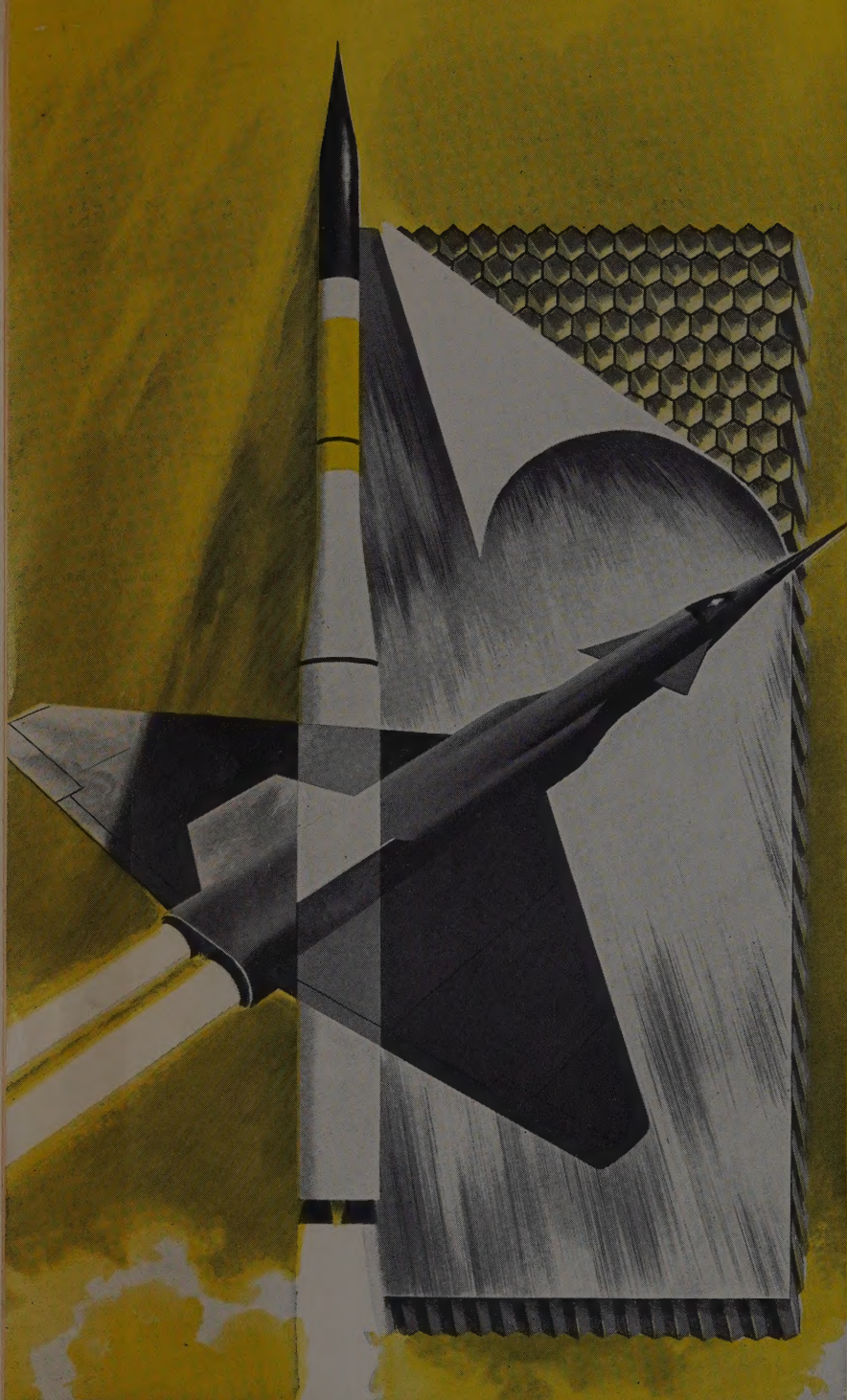
SPECIAL REPORT:

## **Space/Aero Electronics**

JANUARY 1959

Rec-1/9/59 MR. 7





## **AVCOMB®... Crosley's stainless steel honeycomb sandwich**

Designed for tomorrow's high-Mach aircraft and missiles, Crosley's *Avcomb* has been tested under the most rigid conditions, has successfully passed all requirements. Crosley is proud that *Avcomb* was the first stainless steel honeycomb to win such approval.

Now ready for mass production, *Avcomb* is the newest of Crosley's advanced manufacturing techniques, which include the latest metal-bonding and chemical milling methods.

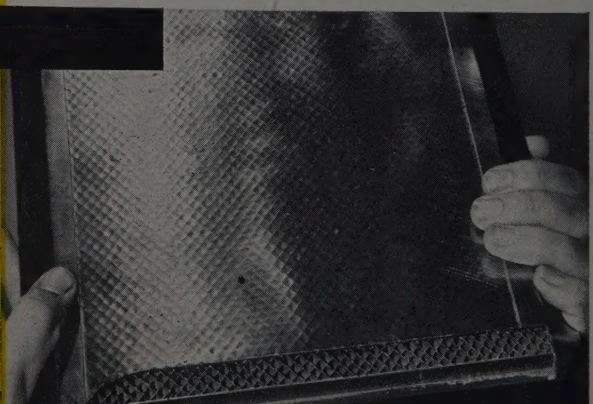
Improved and different production facilities, now being perfected by Crosley, will soon make *Avcomb* available in complex shapes and in very large panels. And costs will be substantially below today's prices.

Together with its associated Avco Divisions, Crosley now offers missile and aircraft manufacturers complete facilities and personnel for:

- *Weapons systems management from initial concept to production.*
- *Research, development, and engineering design of air frames, electronics, control systems, telemetering, automatic test and support equipment, ground handling equipment and logistics.*
- *Production and manufacturing for missile and aircraft systems.*

For further information, write to: Vice President, Defense Products Marketing, Crosley Division, Avco Manufacturing Corporation, Cincinnati 25, Ohio.

**Avco** // **Crosley**



Circle No. 1  
Reader Service  
In Product Re-  
Section.



## Coming Next Month . . . A NEW Format

The February issue of SPACE/AERONAUTICS will come to you in a new format. The outside dimensions will be cut to  $8\frac{3}{4} \times 11\frac{1}{4}$  inches—commonly referred to as "standard size"—and on the inside you'll find a more efficient package for the busy Technical Management reader.

Like many others that you've probably noticed during the past 18 months, these improvements are part of a continuing effort to provide you with the most useful technical information service possible—packaged for easier reading.

New typography, layout and styling were suggested by a professional magazine designer—based on the latest publishing techniques. But even more important, many of the improvements are the result of comments and suggestions by you, our readers.

For instance, over 2,500 of you recently took the time to fill out a 7-page questionnaire about your reading habits and use of SPACE/AERONAUTICS. And almost every one who did so also took the trouble to tell us how we could make the publication more useful and easier to read.

For example, we learned of the trend toward increased filing of technical articles. Better than 8 out of 10 of our readers are making use of SPACE/AERONAUTICS material for this purpose. Many of you commented on the difficulty of filing oversize pages or clipping articles that ran on in single columns for many pages. Many of you asked for some mechanical aid to help file articles for future reference.

Starting in February there will be two major sections of solid editorial—each section will be uninterrupted by advertising. In addition, there'll be a new feature, "Technical Article Abstracts," covering all articles in the issue. All you have to do is cut them out, mount on 3x5 cards and you'll have a permanent reference to all issues of SPACE/AERONAUTICS. To aid you further in your need to "clip and file," some features like "Design Progress" will be printed on perforated pages—making them easy to remove and keep in a design notebook.

Most of you (about 9 out of 10) told us advertising was of definite interest. The majority use the ads to get answers to technical problems. So, even with solid editorial sections, we are making sure that advertising will not be bunched up in other parts of the magazine. You will also find a special reference in every issue which classifies all advertisements by product or service. This will appear immediately before the regular index to advertisers and the "Reader Service Card"—giving you a complete reference to all advertisements in any issue, as well as a direct channel to the advertiser.

SPACE/AERONAUTICS offers you the industry's most complete and authoritative technical information service—in a greatly improved package to make it more useful.

*Bill Maass*

Publisher







## Our new format

The next issue of SPACE/AERONAUTICS will be welcomed by those who clip and file technical articles. Their number, apparently, is legion.

One of the most insistent requests has been for some way to make it easy for you to file material in the magazine. We believe the new format and size will meet some of your filing requirements.

There will be two major sections of solid editorial "uncluttered" by ads. We have also added a new filing aid—"Technical Article Abstracts." These will cover all articles in each issue. You will be able to mount each abstract on a 3x5 card for a permanent reference to all issues of SPACE/AERONAUTICS.

Moreover, some special features—such as "Design Progress"—will be printed on perforated pages, making it easier to remove them for filing in a design notebook.

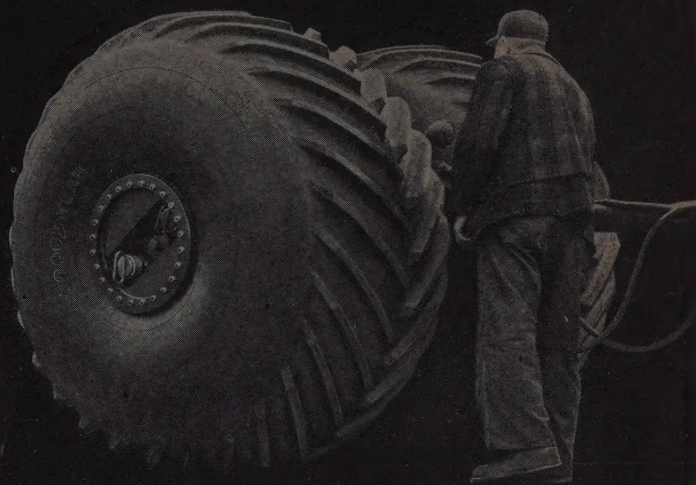
Since advertising is of particular interest to those wanting specific technical information, there will be a special reference section in every issue which classifies all ads by product or service.

The two major sections, Space/Aero Engineering and Space/Aero Electronics, have been designed to give you the best possible way of getting the information you want. It further streamlines our "systems and components" arrangement of editorial subjects.

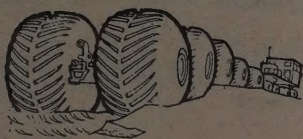
Electronics, on the other hand, because it continues to be of such heavy, specialized interest, is expanded to cover even more material than before.

Randolph Hawthorne  
EDITOR

# Does your weapon system need fuel "on the double"?

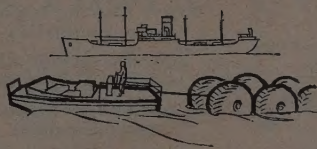


Here — from Goodyear — are ingenious new rubberized containers that offer double dividends: lightweight liquid storage plus unmatched all-weather mobility.



### NEED FUEL THAT ROLLS WITH YOU?

These big Rolli-Tankers hold 500 gallons each, can be towed in long "fuel trains" over roughest terrain. Tire-like containers roll so easily a man can pull one.



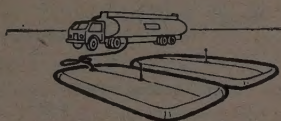
### —OR FLOATS WITH YOU?

Filled with fuel, Rolli-Tankers have natural buoyancy — ride through water, roll right up the beach! Eliminates long-line hoses and pumping.



### —OR COMES BY AIR?

Delivered by air, Rolli-Tankers can be attached to waiting trucks —and rolling—in matter of minutes. Fully loaded tankers survive free falls of 15 feet.



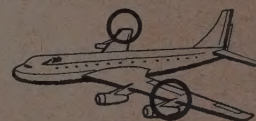
### HOW ABOUT A PORTABLE FUEL FARM?

Called "Pillow Tanks," these tough, rubberized fabric containers can be set up, filled and pumping in 45 minutes. Great where temporary or emergency storage of bulk liquids is needed.



### LOOK! FLOATING FUEL STATION

"Pillow Tanks" in the water serve as "fuel islands"—eliminate stringing of long-line hoses or pumping from remote point. Tanks available in sizes up to 50,000 gallons.



### WANT TO SAVE FUEL SPACE?

Goodyear has pioneered the development of spacesaving fuel cells and tanks for aircraft, boats, vehicles, missiles. This experience can best answer your fuel storage problem.

FOR COMPLETE INFORMATION on these and other new developments in fuel storage and transport, write Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.

AVIATION PRODUCTS BY

# GOODYEAR

Rolli-Tanker—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio



## Technical Management

EDITORIAL: Needed—An Overall Program .....	8	AIRCRAFT MISSILE•ELECTRONICS INTELLIGENCE .....	17
TECHNICAL MANAGEMENT INTELLIGENCE .....	9	Electronics Outlook is Bright in Changing Market ..	22
WASHINGTON BRIEFING: NASA Contractors Face		AIRCRAFT MISSILE•ENGINEERING INTELLIGENCE ...	127
Patent Trouble .....	14	ASTRONAUTICS INTELLIGENCE .....	175
INDUSTRY VIEWPOINT: Military and Industry Must		READERS' ROUND TABLE: We Must Cut Development	
Cooperate on Reliability .....	15	Time! .....	190

## Special Report: Space/Aero Electronics

INTELLIGENCE .....	17	Mathematical Analysis for Minimum Weight and	
Electronics Outlook is Bright in Changing Market ..	22	Space Envelope, Top Reliability .....	64
State of the Art Reports:		DESIGN DIGEST: Parami Scores Missiles in Real Time	70
Inertial Guidance .....	24	Pages from an Engineer's Notebook:	
Radar .....	25	Radar Parameters .....	72
Infrared .....	26	Infrared System Parameters .....	73
Magnetohydrodynamics Opens Up New Electronic		Conversion of Decibels to Degrees .....	73
Vistas .....	28	Atmospheric Attenuation of Space	
Reliability and Stability Most Critical in Satellite		Communications .....	74
Communications .....	38	Gyro Conversion Tables .....	74
Wide Use Foreseen for Applied Thermoelectricity	46	PRODUCT OF THE MONTH .....	105
Spiral Antennas Meet Needs of New Vehicles ....	56	PRODUCT REVIEW .....	106
		DATA REVIEW .....	124

## Aircraft•Missile Engineering

INTELLIGENCE .....	127	Accessory Systems	
PRODUCT REVIEW .....	155	Cabin Pressurization Now Needs Built-In Re-	
DATA REVIEW .....	170	liability .....	142
Propulsion		Materials	
Soviet Development of Nuclear Aircraft Engines	132	Aluminum Oxide Insulation Looks Good for	
		High Temperature Wire .....	150
		Production Engineering	
		Microinch Tolerances with Electric Discharge	
		Machining .....	138

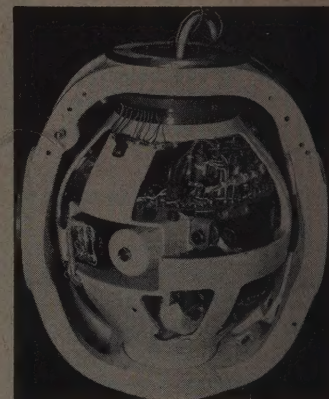
## Astronautics

Magnetohydrodynamics Opens Up New Electronic		INTELLIGENCE .....	175
Vistas .....	28	DESIGN PROGRESS: Honeycomb Housing for Pioneer	
Reliability and Stability Most Critical in Satellite		Instruments .....	178
Communications .....	38	Retro-Rockets and Drag Devices Teamed for Satellite	
		Recovery .....	180

## Features

Look For .....	6	Books .....	185
Calendar .....	7	Product Index to Advertising .....	186
Product of the Month .....	105	Advertisers' Index .....	188
Readers' Round Table .....	190		

The editorial content of Space/Aeronautics is regularly examined for readability by Robert Gunning Assoc., counselors in clear writing. These consultants meet periodically with the editors and discuss comparative readability ratings.



### Cover Story

This month's cover features the first published photo of the three-gyro stable platform that will provide flight data for the North American X-15. The platform, shown within its roll and pitch gimbals, is the heart of an extremely precise inertial system, specially developed for the first U.S. manned spacecraft by Sperry Gyroscope Co., Great Neck, N.Y.

The entire system consists of the stabilized platform, a computer, and a control unit. The first model was delivered to the Air Force last month.

The platform has a volume of roughly 0.446 cu ft and weighs about 27 lb. It contains all its own power supplies, amplifiers, and even a heat exchanger. It is the X-15's basic sensor for critical attitude, speed, distance, and altitude data.

The entire system is designed to direct the pilot from the moment of launch throughout the hypersonic acceleration phase and to provide re-entry control data.

See **Astronautics Intelligence** (p. 175) for details on Atlas orbit shot.



William G. Maass ..... Publisher  
Randolph Hawthorne ..... Editor

### Editorial Staff

Englebert Kirchner Managing Ed.  
Robert M. Loebelson Industry Ed.  
Irwin Stambler Engineering Editor  
Victor DeBiasi Systems Editor  
James Holahan Electronics Editor  
Bernard Kovit Asst. Electronics Ed.  
Kurt R. Stehling Consulting Ed.  
Propulsion & Missiles  
A. N. Weckler  
Washington Bureau Chief  
Joan Bessel Editorial Assistant  
Denis Desoutter London  
Hans Kosman Holland  
Walter P. Moser Switzerland  
Robert Roux France

E. Carlton Arink Art Director  
David Burke Associate Art Director  
N. T. Gravin Asst. Prod. Mgr.  
Vivien L. Lorenz Prod. Supervisor

### Business Staff

William Wessel Asst. Publisher  
David W. Ewald Adv. Sales Mgr.  
G. Peter O'Neill Regional Mgr.  
M. E. Litz New York Rep.  
Robert Keegan Eastern Rep.  
Robert J. Reed Cleveland Manager  
George J. Mehl Cleveland Rep.  
Charles G. Paxson Midwest Mgr.  
William D. Gullickson  
Midwest Representative  
Forrest C. Pearson  
Pacific Coast Manager  
Dwight Jennett Regional Manager  
Barend Broekman European Mgr.  
Michael E. Horne London Manager  
Hy Sirota Promotion Manager  
Roy Ellison Circulation Supervisor  
Eileen Reardon Mgr., Adv. Service

### Editorial & Executive Offices

New York 17, N. Y. 205 E. 42nd St.  
Murray Hill 9-3250

### Regional Offices

Washington 4, D.C., 369 National  
Press Bldg. National 8-2773  
Cleveland 15, Ohio 1900 Euclid  
Bldg. CHerry 1-7788  
Chicago 11, Ill. 737 N. Michigan  
Ave., WHitehall 4-6612  
Los Angeles 35, Calif., 864 S. Rob-  
ertson Blvd. OLeander 5-9580  
London W. 1, England  
24 Baker Street

Amsterdam, Holland  
47, De Lairesestraat

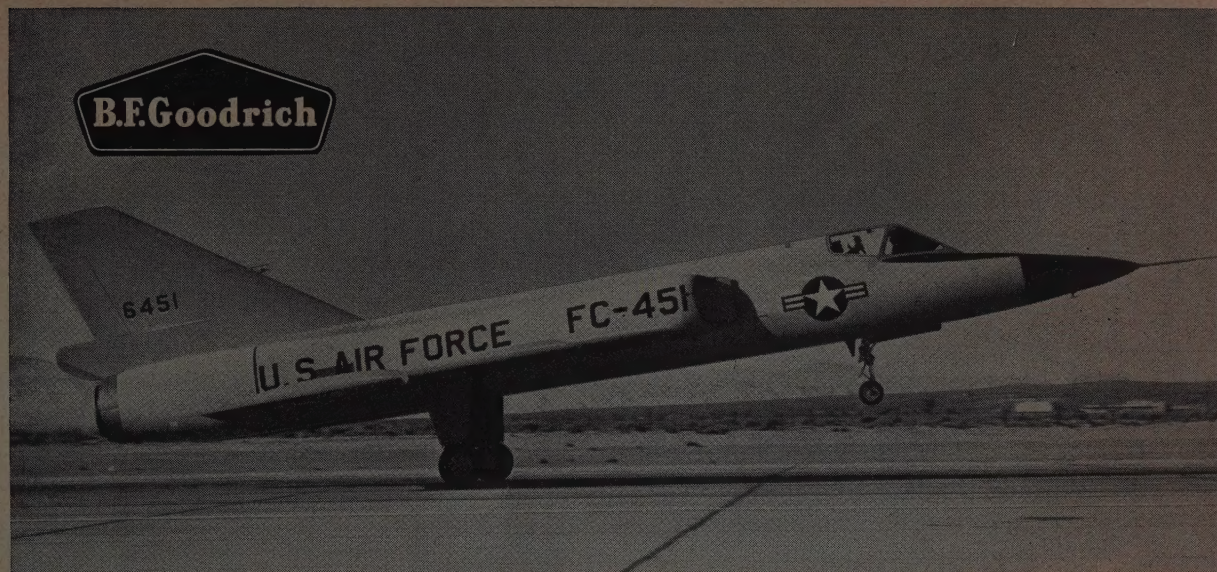
### Published by Conover-Mast Publications, Inc.

B. P. Mast, Chairman of the Board  
B. P. Mast, Jr. President  
William G. Maass Vice President  
A. M. Morse, Jr. Vice President  
A. H. Dix V.P. & Dir. of Cir. &  
Research  
Harvey Conover Jr. Secretary  
Leo Haggerty Treasurer  
John J. Dix Dir. of Midwest Oper.  
E. H. Howard Promotion Mgr.  
L. E. McMahon Production Mgr.  
D. G. Smith Circulation Mgr.

### Other Publications

Business/Commercial Aviation  
Mill & Factory—Purchasing  
Construction Equipment  
Volume Feeding Management  
Conover-Mast Purchasing Directory

**NFP** Associate Members: **EPA**



## B. F. Goodrich Fabric Tread Dimple Tire proved "far superior" in F-106 tests

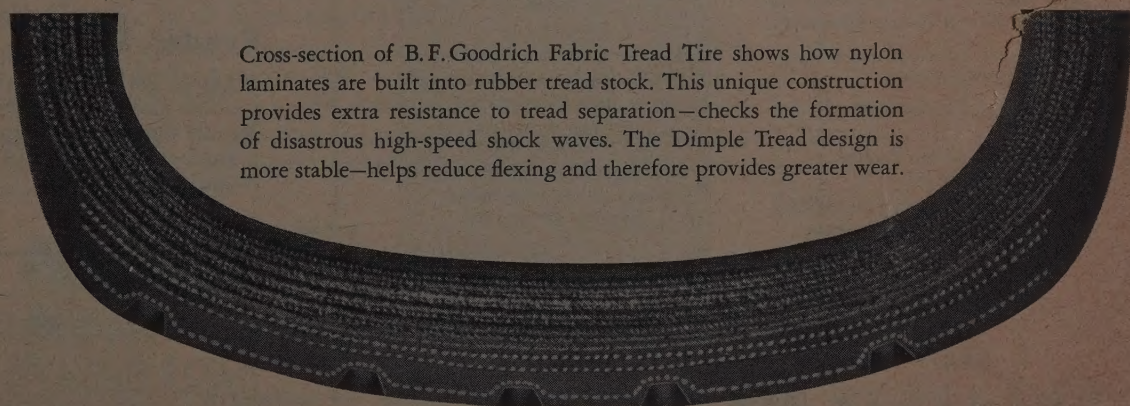
Ordinary high-performance tires used on the F-106 built by Convair, a division of General Dynamics Corporation, just couldn't take the punishment. The stress of high-speed takeoffs and landings literally tore them to pieces.

Then B.F. Goodrich submitted its revolutionary new Fabric Tread Dimple Tire for testing. Even under severe operating conditions, including repeated RTO situations, the tire proved that it could out-perform and out-wear any jet tire known today. As a result, the B.F. Goodrich Fabric Tread Dimple Tire is standard equipment on the F-106 Delta Dart, world's fastest and highest flying all-weather interceptor.

The amazing performance of the B.F. Goodrich Fabric

Tread Dimple Tire is made possible by two exclusive features. Plies of nylon cord are built right into the rubber tread stock to equalize the modulus between tread and carcass. This cuts the amount of heat normally generated by flexing between the two elements of the tire. In addition, the special Dimple Tread design eliminates stress points in the tread and therefore provides greater resistance to cutting and chipping.

B.F. Goodrich Fabric Tread Tires mean safer takeoffs, more landings, for supersonic aircraft of all kinds. Available with either Dimple or Sinewave Tread design. For more information, write B.F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Akron, Ohio.

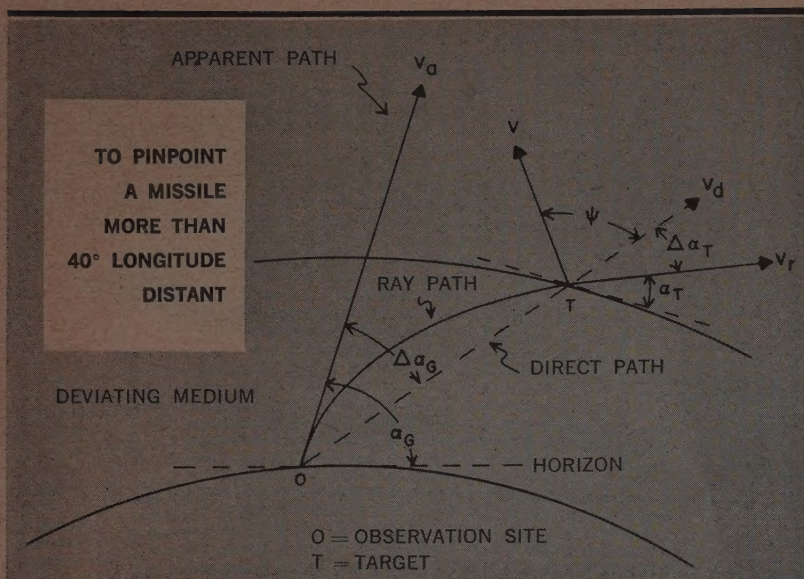


Cross-section of B.F. Goodrich Fabric Tread Tire shows how nylon laminates are built into rubber tread stock. This unique construction provides extra resistance to tread separation—checks the formation of disastrous high-speed shock waves. The Dimple Tread design is more stable—helps reduce flexing and therefore provides greater wear.

# B.F. Goodrich aviation products

Circle No. 276 on Reader Service Card in Product Review Section





## Engineering Opportunities of a High Order in Creating Complex Identification & Tracking Equipments at General Electric's Missile Detection Systems Section

To locate a 15,000-mph missile despite complicating factors such as the varying refractive index of the troposphere and ionosphere, a high degree of systems sophistication is of paramount importance.

Growth opportunities commensurate with the creative and analytical demands implicit in such requirements are open now for experienced electronic engineers at G.E.'s Missile Detection Systems Section in these areas:

- Research & Development of New Detection Techniques
- Initiation & Development of Proposals
- Definition and Direction of Equipment Design
- Engineering Liaison with Military & Engineering-Manufacturing Sub-Contractors

Salaries fully competitive, commensurate with experience  
Write in confidence to Mr. James P. Kinsella, Div. 15 WA.

Missile Detection Systems Section  
HEAVY MILITARY ELECTRONICS DEPT.

**GENERAL  ELECTRIC**

Court Street, Syracuse, New York

### Positions at Several Levels for Electronic Engineers

#### SYSTEMS DEVELOPMENT ENGINEERING (At least 4 years' experience)

RADAR SYSTEMS  
SYSTEMS ANALYSIS  
DATA ANALYSIS  
ELECTRONIC COUNTERMEASURES  
SYSTEMS

#### SYSTEMS EQUIPMENT ENGINEERING ANTENNA DESIGN AND DEVELOPMENT

RF COMPONENTS DEVELOPMENT  
UHF AND MICROWAVE  
RECEIVER DEVELOPMENT  
DATA REDUCTION EQUIPMENT D & D  
VIDEO DISPLAY DEVELOPMENT  
COMPUTER APPLICATIONS

In this issue

# look for . . .

### Nuclear flight in Russia

There can be little doubt the Reds are ahead of us in developing an airborne atomic reactor. How did they do it? A partial answer is given in the article on **page 132**, the first in a series of detailed engineering reports on Soviet aircraft reactor progress.

### Electronics Outlook

As usual, this year's special report on space/aero electronics is introduced by a detailed analysis of electronics' share of the space/aero industry. Turn to this informative article on **page 22** for a review of the trends and trouble spots of the electronics market.

### State of the electronic art

Three of the most important areas of space/aero electronics—inertial guidance, radar, and infrared—are covered in detail in special "state of the art" reports (beginning on **page 24**). Here you'll find expert assessments of the latest development and research trends.

### Magnetohydrodynamics

As we learn to combine the sciences of electrody-namics and hydrodynamics in magnetohydrodynamics, the article on **page 28** points out, vast new possibilities are opening up in fields as diverse as microwave amplification and space propulsion.

### Reader Service

Want to get more information on products or services advertised or mentioned editorially in this issue? Then use our handy Reader-Service Card opposite **page 167**. It's simple—just circle a number, drop the card into a mailbox, and we'll forward your inquiry.

Aviation Operations Magazine, Aviation Service Magazine, and Aviation Age Magazine are combined with Space/Aeronautics Magazine.

All rights to the names Aviation Operations Magazine, Aviation Service Magazine and Aviation Age Magazine are reserved by Conover-Mast Publications, Inc. Copyright 1959 by Conover-Mast Publications, Inc., in the U. S. A. All rights reserved. Entire contents fully restricted. Every effort is made to verify the information published in this magazine. However the opinions of the authors are not necessarily the opinions of the publishers and this periodical accepts no responsibility in connection with any liability which might develop as a result of articles published. Published monthly by Conover-Mast Publications, Inc. Editorial and Executive Offices: 205 E. 42nd Street, New York 17. Single copy \$1.00 except special issues. Subscription U. S. A. \$10.00 annually; Canada, \$15.00 annually; Other foreign \$20.00 annually. Accepted as controlled circulation publication at Philadelphia, Pa. Printed by Periodical Press Corp., Phila. 40, Pa.

Circle No. 277 on Reader-Service Card opposite last page or send personal resume direct to address mentioned above. GIVE HOME ADDRESS

SPACE/AERONAUTICS



# calendar

**January 12-14** — Fifth National Symposium on Reliability and Quality Control in Electronics, Bellevue-Stratford Hotel, Phila., Pa.

**January 13-14**—Symposium on Cathode Ray Tube Recording, Systems Development Corp., Engineers Club, Dayton, Ohio.

**January 21-23**—South West Electronic Exhibit, Arizona State Fairgrounds, Phoenix, Ariz.

**January 26-29** — Tenth Annual Plant and Engineering Show, Public Auditorium, Cleveland, Ohio.

**January 26-29** — 27th Annual Meeting, Institute of the Aeronautical Sciences, Sheraton-Astor Hotel, New York, N. Y. Honors Night Dinner, Jan. 27.

**January 27-29** — Fifth Annual Radar Symposium (classified), Rockham Bldg., Univ. of Michigan, Ann Arbor, Michigan.

**January 27-30** — 15th Annual Technical Conference, Society of Plastics Engineers, Hotel Commodore, New York, N. Y.

**January 28-29** — Fifth Annual Midwest Welding Conference, Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill.

**February 3-5**—14th Annual Technical and Management Conference, Reinforced Plastics Division, Society of the Plastics Industry, Inc., Edgewater Beach Hotel, Chicago, Ill.

**February 12-13** — 1959 Solid State Circuits Conference, Institute of Radio Engineers' Professional Group on Circuit Theory, American Institute of Electrical Engineers' Committee on Electronics and Univ. of Pennsylvania, Philadelphia.

**February 26-March 1**—1959 Engineering Exposition, Balboa Park, San Diego, Calif.. Address inquiries to: 422 Land Title Bldg., San Diego 1, Calif.

**March 3-5**—1958 Western Joint Computer Conference, sponsored by IRE, American Institute of Electrical Engineers and Assn. for Computing Machinery, Fairmont Hotel, San Francisco, Calif.

**March 5-6** — Flight Propulsion Meeting (classified), IAS, Hotel Carter, Cleveland, Ohio.



# KEMET

TRADE-MARK

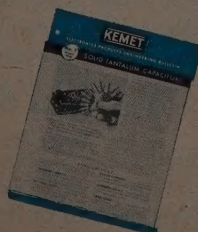
## SOLID TANTALUM CAPACITORS

## PROVIDE UNMATCHED STABILITY UP TO 125°C

The curve at the right illustrates actual leakage current for a "Kemet" 5 mfd. 30 volt capacitor over a 2000 hour test interval when measured at 125°C (not at room temperature). This characteristic is extremely important where equipment must provide stable operation at elevated temperatures.

"Kemet" capacitors offer precision electrical performance over long periods of storage and service life . . . proved temperature stability from -80°C to +125°C . . . and exceedingly low dielectric losses. KEMET COMPANY — supplier of a complete line of solid tantalum capacitors — is not dependent on other suppliers for the mining or processing of tantalum.

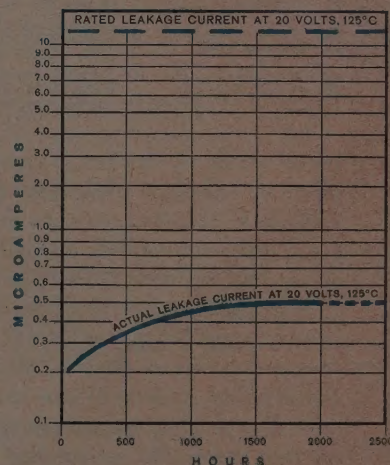
WRITE TODAY FOR FREE  
"ELECTRONICS PRODUCTS ENGINEERING BULLETIN"  
This four-page folder provides performance curves, operating characteristics and specifications.



# KEMET COMPANY

DIVISION OF UNION CARBIDE CORPORATION

OFFICES: 11901 Madison Avenue, Cleveland 1, Ohio



LEAKAGE CURRENT vs. TIME AT 125°C  
"KEMET" K5H30 SOLID TANTALUM CAPACITOR  
(Average of Typical Capacitors)





### CHARACTERISTICS

#### ANALYSIS

- 1 Stainless Steel Ball and Race
- 2 Chrome Alloy Steel Ball and Race
- 3 Bronze Race and Chrome Steel Ball

#### RECOMMENDED USE

- { For types operating under high temperature (800-1200 degrees F.).
- { For types operating under high radial ultimate loads (3000-893,000 lbs.).
- { For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. S/A 59.

**SOUTHWEST PRODUCTS CO.**  
1705-SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Circle No. 279 on Reader-Service Card

## editorial

### Needed: An Overall Program

**W**ALTER LIPPMANN once said that we prefer a disagreeable fact still in the future to a disagreeable remedy in the present. The truth of this threads through the whole fabric of our national affairs.

It shows in the way we face almost any national problem you want to name today. Take just three: Inflation, defense budgets, labor unions.

The danger, the waste, and the evils of each are well known, especially by those in a spot to do something about them. The day is fast coming when either we shall master these problems, or they will master us. But the will to do something about them now is sadly lacking.

Union racketeering, looting of union funds, and lust for power have been spread over the front pages of the press for a year. But Republicans and Democrats stopped even a timid little curb on union activities from being passed. Prospects for a law this year are even less.

**T**HE WASTE in defense spending, in civil government spending programs, and that caused by union monopolies, are major causes of inflation. But who cares enough to do anything about them? Not the Congress. Not the Administration. And, apparently, not the people.

Waste in defense spending stems from lack of a logical, overall strategic plan. If such exists, it does not coordinate a diverse effort to meet a diverse threat. As a result, parts of our efforts negate the effects of other parts, some duplicate others, and some exist merely because they are Congressional "pets." The Soviet threat, however, is a coordinated attack at once military, economic and political.

Despite "reorganization" of the Defense Department, we still have overlapping service roles and missions far beyond what is needed for effective defense. Our weapon system programs are based on these traditional, if modified, roles and missions, instead of on targets and weapons missions.

How else can we justify three parallel IRBM programs—Army, Navy and Air Force? Two parallel ICBM programs, with another coming up? And now, two parallel space flight development and operating agencies, one called "civil" and the other "military"?

**I**NFLATION repeatedly has been called our greatest danger. But efforts to reduce the federal budget have been confined to across-the-board slashing of defense funds. Good programs have been cut or dropped along with the bad. Each service chief is forced to choose which project to drop or cut in favor of one he believes needed for his service role and mission. **The "local" service view prevails over national strategic defense requirements.** An overall strategic defense plan would select the weapons, according to the enemy situation and capabilities, and the cognizant service.

Much grim talk points up the dangers of an inflation "that will curl your hair." Yet we pay \$500,000 a day to store wheat which cost us \$3 billion in subsidy. We don't want this wheat. It is more than we can use. We can't even give it away.

Why, then, do we throw away billions of dollars? Because Democrats and Republicans want the "farm" vote. The money to buy this vote comes out of all our pockets, raising the cost of living.

"The only freedom man can ever have is the freedom to discipline himself," Bernard M. Baruch points out in a recent book. This is the freedom we must use to prevent the discipline of an implacable enemy being thrust upon us.



# technical management intelligence

## **Upsurge due in missiles and civil planes**

**Sales went up in 1958 despite decline in aircraft production**

**NASA plans for taking over ABMA ruled out by "compromise" agreement on Jet Propulsion Labs**

**NASA has its eye on research facilities of all three services**

**Takeover at JPL to come on July 1; Huntsville will assist NASA on some space programs**

**Congress will push for speedup on an airborne atomic reactor**

SPACE/AERONAUTICS industry's prospects for '59 look like this:

Continuing decline in military aircraft production will be balanced by continuing upsurge in missiles, a sales volume roughly comparable to '58, a steady level of employment (about 760,000), and an upturn in commercial aircraft sales.

SALES IN 1958 came to about \$11.8 billion (equal to 1957), even though the number of military aircraft dropped from 5500 to 4000 and the number of commercial transports (almost all piston engine types) fell from 322 to 225. Military missile purchases, which climbed 40 per cent over '57, and inflation made up for the difference.

In '58, total sales of the top 12 airframe manufacturers amounted to \$7 billion, as against \$6.9 billion in '57. Commercial sales over the same period dropped from \$1.6 billion to \$1.5 billion. Earnings for the 12 firms declined from 2.4 to two per cent of sales.

NASA lost an important round in the fight to take over the Army Ballistic Missile Agency at Huntsville, Ala. But NASA's campaign is not yet over.

The "compromise" under which NASA got Jet Propulsion Laboratory (2300 people) at Pasadena, Calif., and the Army retained ABMA (3800 personnel), gave NASA the right to use some ABMA manpower and facilities for civil space programs.

DR. GLENNAN, NASA'S ADMINISTRATOR, indicated the "compromise" was "not without some shortcomings." DOD and NASA will make a joint report to President Eisenhower on the results of the "compromise" within the next year. NASA is certain to point out that there is room for improvement—in other words, that NASA still wants ABMA.

DESPITE NASA'S PARTIAL LOSS in its battle with the Army, the civil space group is getting ready for more fights with the services. It would like to take over USAF's School of Aviation Medicine, Randolph AFB, Texas; Navy's Naval Ordnance Test Station, China Lake, Calif.; and some of the Army's Signal Corps activities at Fort Monmouth, N. J.

Naturally, none of the services will be particularly enthusiastic about losing scientists and facilities to NASA. But it is almost equally certain that Glennan & Co. will end up with more manpower and facilities than they have now.

NASA'S AGREEMENTS with the Army on ABMA and JPL provide:

- JPL will continue work for the Army throughout '59 on the Sergeant ballistic missile, special intelligence studies, aerodynamic testing and research, and communications research. NASA will start reorienting JPL's activities on July 1. Army is transferring \$4 million to NASA to cover JPL activities during the January-June period.

- Army Ordnance Missile Command at Huntsville (including ABMA) will "assist in the development of broad requirements and objectives in space programs" and "in the determination of specific projects and specific methods (including hardware development) by which NASA may accomplish its overall objective." NASA will provide the funds, but the Army will be fully responsible for these assignments.

CONGRESSIONAL ARMED SERVICES COMMITTEES will begin pushing for a speedup in the Aircraft Nuclear Propulsion (ANP) program as soon as Defense Secretary McElroy and other DOD witnesses start testifying on the defense budget for fiscal '60.

The ANP program, currently budgeted at \$150 million a year, now involves "parametric studies" of nuclear airframes and extensive work on nuclear powerplants.

*more on next page*



ANP WORK was cut back last year (from \$250 million annually) on the advice of Dr. James Killian, the President's chief scientific advisor. Even now, despite Pentagon acknowledgments that the Russians "may have a slight lead over the U. S. in this area," there is no DOD policy to change the ANP program "at this time."

This attitude differs sharply from that of high USAF officials. Maj Gen. D. J. Keirn, for example, believes the best type of airborne alert system is the manned, nuclear-powered aircraft.

## **Nuclear plane delayed by misconceptions, says Keirn**

GENERAL KEIRN, who is AF's Assistant Deputy Chief of Staff for Development in charge of nuclear systems and also chief of AEC's aircraft reactors branch, says the ANP project has been delayed by misconceptions and by the desire to be safe instead of sorry.

One of those misconceptions is that chemically powered planes can fly faster and higher than nuclear-powered turbojets. Says Keirn, that's not true of the nuclear engines using chemically powered afterburners.

The USAF's A-plane boss believes the U. S. is now entering "the experimental flight development phase looking toward prototypes," but indicates that DOD has adopted the "fly before you buy" attitude on the A-plane.

ALL this means is that it will be many years before the U. S. has a nuclear-powered bomber or patrol aircraft in service.

Just how much Congression-

al pressure to speed up the ANP program will accomplish is uncertain. Some lawmakers have been fighting to get the program speeded for several years—without much success. But Russian progress may force DOD to change its attitude.

ARMY fired the first important salvo in a campaign to meet the threat of limited wars. If General Maxwell D. Taylor's recommendations are even partially accepted by DOD and/or Congress, it will mean additional orders for the space/aeronautics industry.

The Army's Chief of Staff concedes that "we now have a significant capability to cope with limited wars." But "we can and should take steps to improve it." As Taylor sees it, the services should:

- modernize present equipment,
- improve the strategic mobility of limited war forces,
- pre-plan the use of air-and sealift,
- expand joint planning and training.

## **Army needs: New missiles, light atom weapons, more tactical mobility**

TAYLOR cites the need for second generation missiles, light atomic weapons, improved conventional weapons, "and many new types of air and ground vehicles to advance tactical mobility." Also required are improved light-weight signal communications based on new radio equipment.

"As the Army lightens its loads," Taylor explains, "we

hope that our sister services will modernize the sea- and airlift upon which we depend for our strategic mobility." Taylor's bid for allocation of a specified amount of air and sealift for use in a limited war would almost certainly entail the procurement of additional cargo aircraft by USAF and Navy.

## **Federal R&D spending reported on steady increase**

NATIONAL Science Foundation study shows federal expenditures for R&D rose 13 per cent last year, will climb another nine per cent in fiscal '59. NSF says \$3.9 billion will be spent on R&D in this fiscal year. (Not included in this is \$800/900 million that DOD spends for R&D support out of production funds.) About 90 per cent of this total, NSF estimates, is being used for actual R&D; the remainder represents an increase in facilities.

DEVELOPMENT, which historically accounts for the bulk of federal R&D spending, will take \$2.243 billion this fiscal year. Basic research will account for \$281 million in 1959.

Largest Government spender is the Defense Department. Its R&D expenditures will rise from \$2.085 billion in '57 to nearly \$2.4 billion in '59.

AIA'S plan to fight for outright repeal of the Renegotiation Act has been toned down. AIA now sees liberalizing amendments as more likely possibilities than complete elimination of the law.

House Ways and Means Committee is expected to hold full hearings on the law, sched-

uled to die on June 30. But the continuing flow of defense orders makes it politically inexpedient for Congress to let the renegotiation idea die out.

AIA member companies have been assessed up to \$10 million in excess profits by the Renegotiation Board. As a result, the industry would welcome the demise of the whole renegotiation concept. AIA maintains that there is little incentive in incentive-type contracts if another Government agency tries to take away the added earnings after negotiations with the military services have been approved.

AIA's position in future testimony before the Ways and Means Committee is still being firmed up. But the association is certain to seek at least:

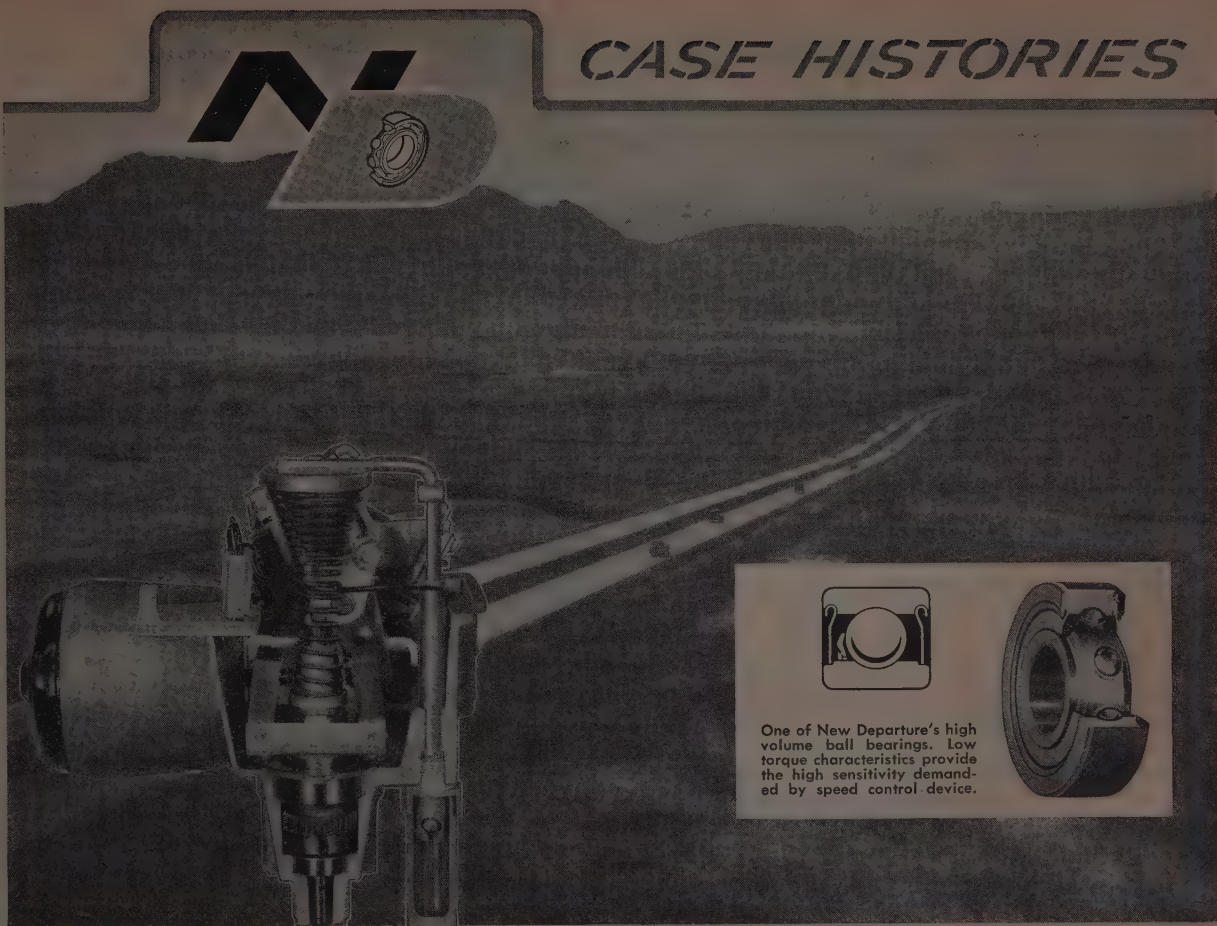
- permission to appeal Renegotiation Board decisions to U. S. Tax Court,
- that the Board reveal the considerations it takes into account in making a ruling of excess earnings,
- that the Board consider the earnings of other industries in its decisions.

## **Privately built plants for production of solids?**

EXPANDING use of solid propellant rocket engines will require additional engine plants. DOD is planning to have these financed by private industry where possible.

Dudley C. Sharp, Assistant AF Secretary for Materiel, who also reflects the views of the Army and Navy on this subject, believes the old industrial mobilization concept of standby war plants is not suited to our present idea of a force in





One of New Departure's high volume ball bearings. Low torque characteristics provide the high sensitivity demanded by speed control device.

Photo: Courtesy Perfect Circle Corp.

## **ND Bearing Solved Response Problem In New Automotive Speed Control Device!**

### **CUSTOMER PROBLEM:**

Extensive testing revealed sluggish response of automobile speed control device.

### **SOLUTION:**

N/D Sales Engineer, in cooperation with manufacturer, recommended replacing existing pure thrust bearing and bushings with New Departure double-shielded ball bearings. These light-duty, non-loading groove bearings, with uninterrupted ball raceways, withstand radial and thrust loads in any combination. This

change resulted in virtually friction-free operation of the speed control device, correcting the response problem. What's more, these New Departures eliminated a lubrication problem and simplified assembly and maintenance.

Perhaps there's a New Departure automotive production ball bearing that will help solve a problem in your product . . . or produce an over-all cost savings. For more information, write Department H-1.

Available through United Motors System and its Independent Bearing Distributors.



**NEW DEPARTURE**

**DIVISION OF GENERAL MOTORS, BRISTOL, CONN.**

NOTHING ROLLS LIKE A BALL

Circle No. 280 on Reader Service Card in Product Review Section

more on next page

being. DOD's policy is aimed at obtaining "an industrial base which is adjusted to firm weapon program needs, and is privately financed to the maximum degree . . ."

ARPA'S program involves a two-pronged approach to defense against ballistic missiles, re-entry research, satellite detection, solid propellants, and military space missions. Dr. Herbert F. York, ARPA's chief scientist, describes the projected work this way:

#### • *Ballistic Missile Defense*

—One approach is based on the present state of the art. Among other items, it covers the Nike-Zeus, its radar, computer, and rocket, and the USAF's Ballistic Missile Early Warning System. Later work involves better defenses against second-generation ICBMs, including advanced radar, power tubes, and reference computers.

#### • *Re-Entry Research*

ARPA plans to find out what interactions take place when a ballistic missile nose cone re-enters the atmosphere, especially in the way of ionization and infrared and possible optical signals.

#### • *Satellite detection*

—One important projected study involves the observation of infrared signals.

#### • *Solid propellants*

—ARPA is primarily interested in the fuels themselves. Other work will involve components that can withstand the temperatures resulting from the new fuels.

#### • *Space program*

—Work will involve larger boosters (e.g., the forthcoming 1.5 million pound thrust cluster), high energy liquid propellant stages to be used on top of ICBMs, and space vehicles themselves, especially the prob-



# THE PERCEPTRON

A RESEARCH TOOL FOR THE STUDY OF PERCEPTION,  
MEMORY, AND THINKING BY MACHINES



## A NEW FRONTIER

AT CORNELL AERONAUTICAL LABORATORY

Currently under study at C.A.L. is a unique non-biological system capable, without human assistance, of absorbing, identifying, classifying, memorizing and utilizing data to form concepts. Extending the basic theory of the Perceptron and exploring its potentialities is a current C.A.L. research project. We seek to advance and enlarge scientific and engineering knowledge in the area of artificial intelligence. It is a goal that requires imaginative men motivated by an urge to breach barriers. To qualified people, we offer participation in advancing this exciting new field in a climate conducive to personal progress and ready recognition of individual contributions and attainments.

CORNELL AERONAUTICAL LABORATORY, INC. of Cornell University

### WRITE FOR FREE REPORT

The story behind Cornell Aeronautical Laboratory and its contributions to aeronautical progress is told in a 68-page report, "A Decade of Research." Whether you

are interested in C.A.L. as a place to work or to watch, you will find "A Decade of Research" both useful and pertinent. Mail the coupon now for your free copy.

J. G. Ruch

CORNELL AERONAUTICAL LABORATORY, INC.  
Buffalo 21, New York

Please send me "A Decade of Research."

Name \_\_\_\_\_

Street \_\_\_\_\_

City \_\_\_\_\_

Zone \_\_\_\_\_

State \_\_\_\_\_

☐ Please include employment information

Circle No. 281 on Reader Service Card opposite last page or send personal resume direct to the address mentioned above. GIVE HOME ADDRESS

## MANAGEMENT INTELLIGENCE

lems of their orientation, stabilization, and power supplies.

NAVY and Air Force each canceled a major weapon system because the vehicle arrived too late for military requirements.

Martin got the word to stop production of the P6M SeaMaster flying boat after 14 have been built. Six development models are already flying.

BELL AIRCRAFT was told by AF that the GAM-73 Rascal is out. The cancellation does not affect any of the air-to-surface missiles already contracted for. But orders for spares and other logistic support equipment are being cut back.

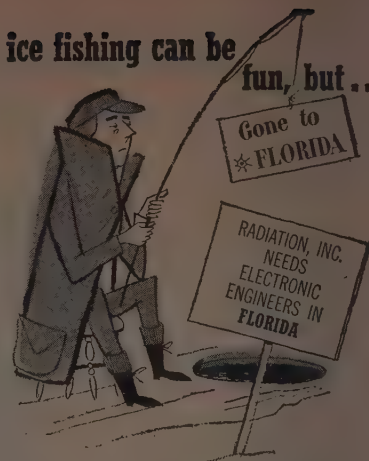
### Technical advances, fund shortage got P6M the axe

P6M HAS four Allison J71 turbojets in the development models, will become supersonic when production aircraft are fitted with P&WA J75s. Navy's decision to give up on SeaMaster resulted from money shortages for fiscal '60 as well as technological advances since the plane was first ordered more than five years ago.

RASCAL, which has been fired from B-47s and B-52s, is to be replaced by AA's GAM-77 Hound Dog. To be carried by the B-52Gs now coming off the line at Boeing-Wichita, this missile has superior performance.

AS WE go to press, still another cancellation is announced: Fairchild was told by USAF to drop work on its Goose decoy missile originally slated for SAC. Status of Goose's J83 jet engine, also a Fairchild design, remains undecided.

ice fishing can be fun, but..



...even the fish like the Florida sunshine. Engineer fishermen at Radiation, Inc. can enjoy their sport the year around.

We have many openings for challenging and rewarding work in design and development. Radiation is well known in DATA PROCESSING, TELEMETRY, ANTENNAS, and other areas of MISSILE ELECTRONICS. Our stable growth pattern indicates a secure future with professional growth for engineers with ideas and energy. Write today for complete details on opportunities available. If you qualify, you too can live and work where living is pleasant and work a challenge.

Technical Personnel Dept. 15



Circle No. 282 on Reader Service Card

Over 85% of the torque wrenches used in industry are

## STURTEVANT

### TORQUE WRENCHES

Read by Sight, Sound or Feel.

- Permanently Accurate
- Practically Indestructible
- Faster—Easier to use
- Automatic Release
- All Capacities

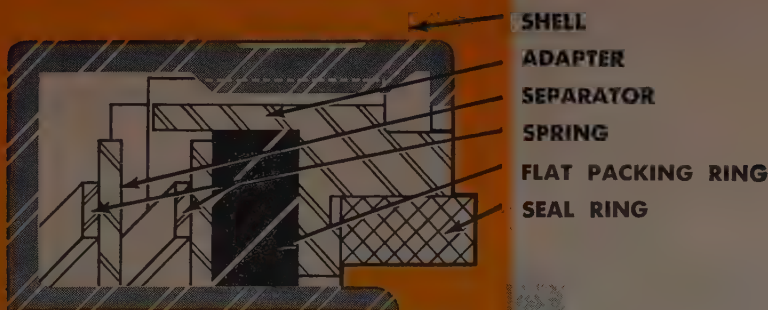
in inch grams... inch ounces... inch pounds... foot pounds  
(All sizes from 0-6000 ft. lbs.)

Every manufacturer, design and production man should have this valuable data. Sent upon request.

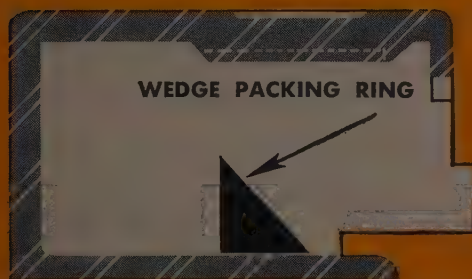
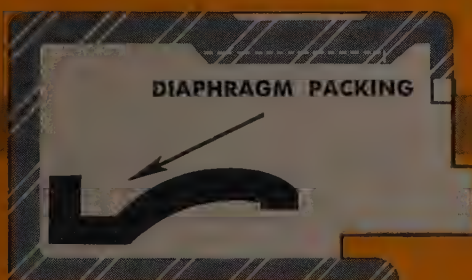
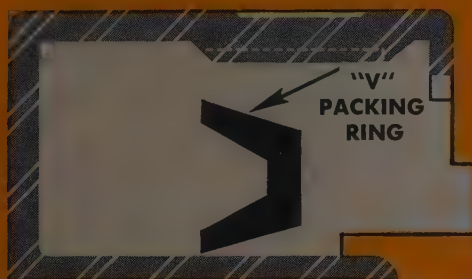
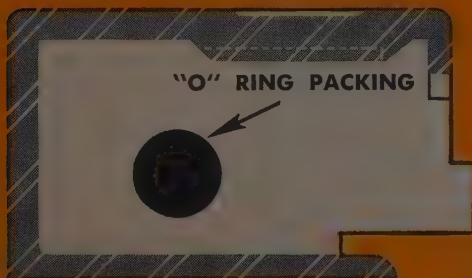
PA STURTEVANT CO.  
ADDISON QUALITY ILLINOIS

Circle No. 283 on Reader Service Card  
SPACE/AERONAUTICS





# GITS



### VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

*Extra Flexibility For  
Your Seal Applications!*

## ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope—with your choice of the five seal packing arrangements illustrated at left—permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements of the aircraft and missile industry.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information.

## GITS BROS. MFG. CO.

1850B South Kilbourn Avenue • Chicago 23, Illinois

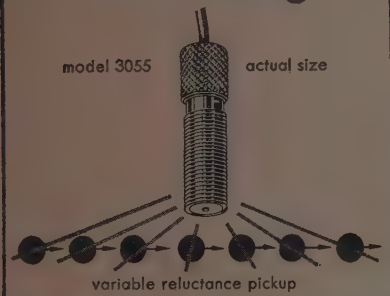
**NEW!** Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.



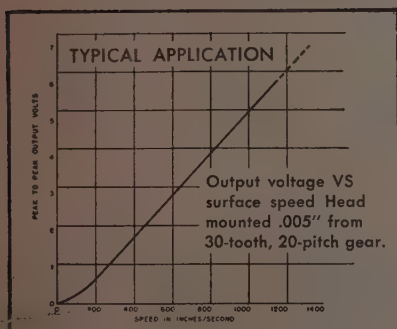
## SUBMINIATURE, HI-TEMP MAGNETIC PICKUP

...solves problems in

# Control, Indicating, Telemetering, Actuating



**Generate AC voltage  
from  
mechanical motion  
without contact**



Use with: electronic control circuits, counters, electric devices.  
Use for: motion, speed, vibration, torque measurements; mechanical operations.

Also specially designed transducers for:

- metering liquid rocket fuel.
- sensing over-speed of turbines.
- generating frequency in drones.

Send for Bulletin & Field Engineer's Name



4501-C N. Ravenswood  
Chicago 40, Ill.  
Canada:  
Atlas Radio Ltd.,  
Toronto 8008

Circle No. 285 on Reader Service Card

## washington briefing

by A. N. Weckler, Washington Bureau Chief

### NASA contractors face patent trouble

NASA (National Aeronautics Space Administration) will follow the same contracting procedures as the armed services, with one exception — patent rights on inventions will become the property of the government.

This practice affects both companies and individual scientists and engineers where the discovery has some significance in space technology. Under Department of Defense procedures, where a contractor invents, he makes no charge to the government for the use of his invention, but does retain ownership in the patent.

Since R&D contracts can be notoriously lean as far as profit is concerned, one of the incentives for the company to engage in R&D is the yield that can possibly be obtained from a commercial use of the invention. In many instances, the company gives the individuals who develop the invention an interest in the patent.

Under the "Space Act" that set up NASA, all patent rights belong to the government. If there is an NASA contract, neither the company nor the inventor has any ownership rights—even if the discovery is made on the inventor's own time, in his own laboratory, and he uses his own materials.

The Act also says any company or individual working under an NASA contract must promptly furnish full technical information on any discovery made in course of the contract.

The Act even goes a step further and says no patent can be issued by the Patent Office for any invention that appears

to the Commissioner of Patents to have "significant utility in the conduct of aeronautical and space activities" unless the applicant makes written oath on the full facts on how the invention was developed.

If NASA does not intervene within 30 days, the patent can be issued. But NASA can come back over a period of five years and request title to the patent, if it believes that the facts presented by the inventor were false.

There is a precedent for this kind of regulation. Under the Atomic Energy Act, the government retains patent ownership, and in fact has taken patent title to a vast amount of technical data.

But there are two essential differences between inventions in nuclear fields and in space:

(1) Nuclear technology was basically a new art—developed at great cost by the government, involving materials and techniques requiring continued government control. In contrast space is an integral part of the 50-year-old technology of flight. This technology was developed under a certain set of rules. The Space Act now switches the rules in the middle of the game.

(2) Nuclear technology can be segregated. It is separate and different from other technologies. In contrast, invention in space involves the environment, conditions, and hardware that are basic to the art of flying.

It is quite plausible that a company could be developing a unit for a non-astronautic mili-

tary vehicle and at the same time be working on an adaptation of this unit for an NASA space project.

Under the military contract, the company would get the patent ownership if some commercial adaptation were possible. At the same time, it would be forfeiting these rights under the NASA contract.

There is little need to show that the Space Act provision dealing with inventions is impractical. There are few who will defend it. The American Bar Association, the American Patent Law Association, the Aircraft Industries Association — all join in questioning the wisdom and practicality of the patent ban.

NASA spokesmen show no enthusiasm for the provision. In fact, they point out that they did not advocate such a regulation.

Yet these patent provisions are now law. An effort will be made in the new Congress to get the law amended.

In the meantime, NASA is proceeding to establish criteria under which the government might forego ownership of space patents. NASA must show it is serving the "interests of the United States" before it can waive government ownership.

NASA's patent criteria will be published in the Federal Register and circulated among the industry. After a while, they will be adopted as standard operating practice—unless, of course, Congress moves in and changes the law, making everybody a bit happier.



# industry viewpoint

by Robert M. Loebelson, Industry Editor

## Military and industry must cooperate on reliability

**A**LL over the space/aeronautics industry, voices are being raised that call for more reliability in today's and tomorrow's military equipment. One of these voices belongs to Maj. Gen. Albert Boyd, now retired and vice president in charge of Westinghouse Electric's Defense Products Division, and once one of USAF's top test pilots.

Says Boyd: "We're moving into an age in which reliability and quality control are far more important than they were in the past. To meet the threat, our equipment must function properly. The need for reliability is just as evident in Mach 2 planes as it is in missiles."

Boyd, who spent a large part of his military career in R&D believes there are several ways of approaching the reliability problem.

"In the first place, industry's quality control people, who now report to the production or engineering manager, should be placed on a higher level and report directly to the top man in their echelon," Boyd explains.

"These quality control specialists should participate in design planning and the design approach, from the start of the project to the time when the system is in service.

"Another way to insure reliability is to rotate the quality control people with others from engineering, production, and maintenance. In that way, each group gets to know the others' problems."

The Westinghouse v-p believes that environmental testing is as important as quality control.

"Whenever a program is compressed, testing suffers most," Boyd declares. "This always costs time and money. In the long run, it would be far less costly to do the job properly in the first place. What we really want to accomplish is to put the 'fix' in the weapon system before it is delivered and save millions by eliminating modifications and retrofits."

Boyd thinks both the services and industry can



MAJ. GEN. ALBERT BOYD (USAF, ret.), vice president, Defense Products Div., Westinghouse Electric Corp.

contribute to greater reliability. "The military can and should provide greater financial incentives for meeting quality specifications," he says. "And there should be corresponding penalties for not meeting those specifications.

"Military programmers should also lay down requirements that are realistic and within the state of the art," Boyd adds. All too often, he points out, the equipment is too complex for the job it is designed to do. "The industry often permits its engineers to devise weapon systems that are unnecessarily complex—systems that meet unnecessarily complicated specifications."

Military contractors should refuse to accept requirements that can't be met, Boyd declares. "For financial reasons, the industry often refuses to tell the military the job can't be done. It's up to the industry to control the situation and insist on qualified people to write requirements."

Boyd insists that electronic equipment is now less reliable than other systems in aircraft and missiles. "We've accepted and lived with unsatisfactory electronics in the past," he states. "But we should not continue to accept this."—End

work in the fields of the future at NAA



## TEST EQUIPMENT ENGINEERS

If you've been looking for an opportunity to explore new engineering territory, the positions now open in our electronics test equipment group may be right down your alley.

We need engineers to do research and development based on an entirely new electronics test equipment philosophy. Briefly, the job involves design of test equipment and analysis of electronics designs submitted by vendors and subcontractors. This is one phase of our work on advanced weapon systems B-70 and F-108.

A BSEE, plus experience, can qualify you.

For more information please write to: Mr. P.A. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 15, Calif.

THE LOS ANGELES DIVISION OF

**NORTH  
AMERICAN  
AVIATION, INC.**



Circle No. 286 on Reader Service Card or send personal resume direct to above address. GIVE HOME ADDRESS



# EASTERN... pioneer in

# MISSILE

## auxiliary power subsystems

Eastern has developed miniature, high-output units that give reliable performance in missile auxiliary power systems. Coordination with developers at the planning stage permits Eastern continually to engineer lower weight units that allow more fuel load for longer flight duration. Eastern's experience as pioneers of the thermal frontier provides the all-important knowledge to solve temperature problems at each stage of missile development.

### HYDRAULIC POWER UNITS

Miniature high-speed gear pumps are powered by aircraft motors up to 24,000 R.P.M., or direct-driven by the turbine with little or no reduction gearing needed. Missile design engineers get maximum flexibility, reliability, and simplicity with separate hydraulic systems. Eastern has produced power packs with capacity to 1.5 G.P.M. at pressure to 2,500 P.S.I. Units are completely sealed and have pressurized sumps for operation at any altitude and attitude.

### ELECTRONIC TUBE COOLING UNITS

Liquid cooling of heat-producing electronic equipment is an efficient, reliable control of temperatures within safe operating limits. By creating designs based on pioneering experience, Eastern provides compact, lightweight equipment for up-to-the-minute missile needs that meet military requirements.

Cooling units have 50 to 50,000 watts dissipation rates, and refrigeration-type cooling units are furnished from 100 to 6,000 watts. Come to the leader in the field for complete and creative engineering help.

### EASTERN PRESSURIZATION UNITS

Vital electronic systems that depend on a supply of precisely controlled dry pressurized air are protected by these units. A continuing program of research and development on compressors, dehydrators, and air control systems insures that your Eastern pressurization unit features the very latest advances in this field for compactness, high temperature resistance, and reliability. They are custom-made to your special needs and meet rigid military specifications.

airborne  
systems

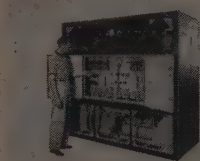
hydraulic  
power

cooling

pressurizing

ground  
guidance  
systems

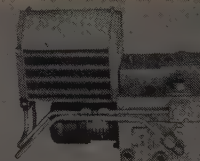
## TESTED reliability in auxiliary power



Pressurizing-dehydrating unit used in tracking and guidance system of ground-based missile controls.



High-speed gear pump provides hydraulic power to missile as integral part of APU system.



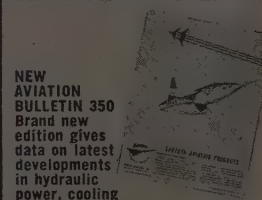
Cools high-powered electronic tubes in guidance sections of missiles.



Eastern power-pack gives hydraulic power for missile elevons and wing-folding actuators.



Maintains sensitive reference component within exact temperature limits. Dissipates 350 watts by "boiling off" water in supply tank.



NEW AVIATION BULLETIN 350 Brand new edition gives data on latest developments in hydraulic power, cooling pressurization. Send for copy today.

Circle No. 287 on Reader Service Card In Product Review Section



# EASTERN INDUSTRIES, INC.

100 SKIFF STREET, HAMDEN 14, CONN. • West Coast Branch Office: 1608 Centinela Avenue, Inglewood 3, Calif.



# aircraft • missile electronics intelligence

## **Transistor has fused aluminum-silicon junction**

FIFTIETH OF MILLIMICROSECOND is what Sperry Semiconductor Div. engineers estimate to be the switching speed of their new silicon junction avalanche transistor. They also report no measurable delays or recovery times.

Working element of the switch is a fused junction of aluminum and silicon. Diameter of the junction layer is 0.002 in., with a thickness of  $4 \times 10^{-6}$  in.

## **Slight voltage rise spreads electron avalanche**

ATOMIC MECHANISM in the junction layer, says Sperry, blocks current flow until triggered by a bit of computer information in the form of a small voltage pulse. Slight increase in voltage starts an electron avalanche that almost instantly spreads throughout the layer, carrying the current across the junction.

Sperry sees a wide range of uses for its device in missile and space vehicle systems.

## **Mesa transistor called most significant advance in commercial transistors since diffusion**

MESA GERMANIUM TRANSISTORS are in production at Texas Instruments. Calling the mesa the most significant advance in commercial semiconductor technology since the discovery of the diffusion technique, TI claims it will provide the highest frequency response, switching speeds, and power capabilities now attainable. Switch speeds are in the millimicrosecond range. Alpha cutoffs of 250 mc are typical of the mesa, says TI.

The original mesa transistor was developed and produced by Bell Labs. Motorola was the first to produce mesas on a large scale. Mesas figure prominently in the new Nike-Hercules electronics, are a natural for other missile systems. (Raytheon also has a mesa type in development.)

## **Arinc started Kahn SSB tests with special 2.5-kw transmitter**

KAHN SINGLE SIDEBAND tests finally got underway at Arinc's leased transmitter at Centereach, N. Y. A 2.5-kw Wilcox 96A AM transmitter was adapted to the Kahn system so that peak envelope power on single sideband is 10 kw. The adapter is so installed that the transmitter can work either full carrier AM or full carrier SSB.

Arinc reports that, with the Kahn technique, undesired sideband and third-order distortion is down some 30 db.

The transmitter will be used by Pan Am and Eastern airliners in the Caribbean area. So far no operating reports have come in. Tests are to check the improvement—if any—the Kahn system gives over conventional methods.

## **Kahn system appears to be the only one for a smooth transition to single sideband**

ARINC IS PARTICULARLY INTERESTED in the Kahn system, mainly because it might offer a quick and inexpensive way of converting its many ground comm stations to SSB while letting them work conventional double sideband AM during the transition period. To date the Kahn system appears to be the only one that will do this without intolerable distortion.

Arinc, however, does not feel the Kahn system (a full-carrier SSB type) will buy enough improvement over conventional systems to justify its use for airborne SSB.

ON THE STRENGTH of developments so far, it looks as though U. S. airlines will go to suppressed-carrier SSB but will demand AFC in the receiver and a floating carrier in the transmitter. These latter capabilities would be needed when higher airliner speeds (with resulting Doppler shift) and/or data link become available.

AGACS (Air Ground Air Communications System), being developed for Federal Aviation Agency by RCA, may also be built to work on HF comm channels. Airlines have been prodding the agency for this particular feature.

Speaking for the airlines, Arinc has also been asking that AGACS modulation (on both VHF and HF links) be compatible with existing airline equipment. It points out this "will shorten the implementation time cycle by at least five and possibly by as much as 7-10 years. . . ."

more on next page

## **Operation on HF communications channels foreseen for AGACS**



BECAUSE of incompatibility, Arinc is against the carrier shift method originally proposed as the modulation for AGACS. It would prefer, for instance, some sort of tone modulation even though it might be several decibels inferior in performance.

AIR FORCE disclosed a high rate of recovery of recorded scientific data from some of its Thor and Atlas shots carrying the operational nose cone. Mounted in the GE-developed nose cone (which fits both missiles) is a data recovery capsule that is ejected some time before the re-entering missile impacts (see *S/A*, "Capsule Collects Data During Re-Entry," Dec. '58, p. 150).

Since re-entry testing is usually done over water, the 18-in.-diameter plastic sphere is strong enough to withstand impact and light enough to float. If, for any reason, the telemetered flight data are interrupted, the canned data fill in the gaps.

According to GE, Ampex makes the tape recorder, Allied Chemical supplies the Du Pont urethane foam, and Standard Plastics molds the sphere's parts.

## **Infrared adjunct to fire control for Century fighters**

CENTURY series fighters will be revamped by USAF to add at least two more years of operational life. One new wrinkle will be an infrared adjunct to fire control system.

Convair F-102 and F-106 IR contracts are expected to be let soon. The systems in these airplanes will be much more sophisticated than the

simple IR viewer used in Lockheed's F-104.

NAA F-108 fire control system, in design at Hughes Aircraft, will have integrated radar-IR sensors. NAA B-70 and A3J will use IR detectors for defense.

ATLAS guidance for first 2-3 operational ICBM squadrons will be the radio command system made by GE's Heavy Military Electronics Dept. This is the guidance used on the first Atlas to travel the missile's full 6000-mile-plus range.

## **Electrostatic and nuclear spin types among advanced gyros under study**

ELECTROSTATIC gyro is being studied by Minneapolis-Honeywell under Navy contract. General Precision Labs is working on a nuclear spin gyro under a \$83,000 WADC study contract.

Arma, Autonetics, GE, Gulton Industries, Maxson, Motorola, and Northwestern U. are among others exploring "blue sky" methods of determining direction and measuring acceleration. In many cases, the work is financed with private funds. So far a breakthrough—if one is to come—seems years away.

FLAME attenuation of S-band signals has been largely responsible for opening up of C-band for missile tracking and ground guidance systems. RCA's FPS-16 instrumentation radar, widely used for tracking, operates on C.

AIRBORNE gyro compass is in the works at both Arma and Laboratory for Electronics.

Both projects are company-financed.

DETECTION over 200,000 miles is the aim of an Avion scheme announced at recent American Astronautical Society meeting in Washington, D. C. The system uses eighth-magnitude stars as background, scans a wide field of view with either IR or optical sensor.

If an object such as a missile or satellite appears in the field of view, at least one of the pinpoints of starlight would be blanked out. Successive images would be stored and compared electronically for differences.

Avion says its system could be installed in a satellite to watch for enemy ballistic missiles.

IM-99B Super Bomarc will have triple-threat guidance—probably command radio via Sage for launch and early flight phase, inertial for midcourse, and infrared homer for terminal phase. Minneapolis-Honeywell reportedly will make the inertial system.

BOMARC I uses Lear three-gyro stable platform. The gyros are one-degree-of-freedom, floated types. Whole package costs around \$26,000.

Similar table is made by Lear for Nike-Zeus.

MINIATURE high resolution pulse radar developed by Army's Diamond Fuze Labs operates on X-band, with pulse width of 10 millisec and rep rate up to 150 kc. Peak power is 150 W. Range discrimination is 10 ft. The set has no "blind" range, say its designers, and has a statistical accuracy of about a foot.

The modulator uses a block-

ing oscillator and ferrite-cored transformer to pulse a L3028A miniature X-band magnetron. The receiver has a 400-mc, four-tube IF strip with 50-mc bandwidth and 50-db gain.

## **Ascop analyzers and marker use concepts of statistical telemetry**

STATISTICAL telemetry, long talked about in theory, has finally been put into hardware. Associated Science Corp. of Princeton (Ascop) says this month it will deliver production versions of three units that embody the statistical data handling concept.

THE concept is based on the fact that most of the high frequency data telemetered from missiles and aircraft is random in nature. It can be analyzed at the source, and the meaningful information can be sent down as low frequency data. Obviously one of the fruits of such a system is bandwidth conservation.

On the minus side, many missile manufacturers object to the additional complexity in the airborne package that, they say, the statistical concept involves.

ASCOP'S three airborne units are all solid state devices:

- an airborne spectrum analyzer, weighing less than seven ounces and occupying less than 25 cu in.,
- an amplitude probability analyzer, weighing less than two ounces and occupying six cubic inches,
- a time-of-occurrence marker, weighing three ounces and occupying three cubic inches.

The probability analyzer



ives a plot of vibration ampli-  
ude vs probability that a given  
plitude will appear in the  
andom signal. The time mark-  
marks the exact time at  
hich a transient occurs.

ABLE between Canada and  
otland has been suggested by  
ernational Civil Aviation  
rganization for air traffic con-  
rol and weather communica-  
ons on world's busiest inter-  
ational air route—which also  
always has had communica-  
ons troubles.

ICAO had previously  
lanned to set up a forward  
atter link. It dropped the  
lea when none of the scatter  
makers would guarantee reli-  
ble communications to the de-  
gree that ICAO wanted.

IF IT goes through, the cable  
l be 2500 miles long, span-  
ing the Atlantic via Green-  
and and Iceland. It would be  
ompleted in '61.

FEDERAL Aviation Author-  
y will absorb CAA's Indian-  
opolis (Ind.) Technical Devel-  
pment Center in its own R&D  
ureau by the middle of this  
ear. The Bureau will be  
taffed by the technical people  
f the former Airways Mod-  
ernization Board. Its main fa-  
ilities are at the former Naval  
Air station in Atlantic City,  
N. J.

NEW type of sub detection  
system will be used in some  
50 Lockheed Neptune Navy  
control planes. Half of Lock-  
heed's \$36 million contract  
will be spent for electronics to  
detect subs "at greater ranges  
than ever before."

It is believed the system  
will be built around the APS-  
10 airborne search radar in  
he works at Texas Instru-  
ments.

more on page 21

for speed . . . accuracy . . . flexibility in data handling . . .

## RMD-THIOKOL SPECIFIES TELE-DYNAMICS SYSTEM

To meet a stringent requirement by Reaction Motors Division of Thiokol Chemical Corporation, Tele-Dynamics Inc. is providing a broad new concept in automatic data handling systems . . . for use at Naval Ship Installations Test Facility (NSITF), Lakehurst, New Jersey.

Tele-Dynamics invites your inquiries concerning any problem requiring the system approach to remote instrumentation.

# TELE-DYNAMICS INC.

*A Raymond Rosen Corporation*

5000 PARKSIDE AVENUE • PHILADELPHIA 31, PENNSYLVANIA

Western Regional Offices: 15016 Ventura Blvd., Sherman Oaks, Los Angeles, California

305 Washington Avenue, S.E., Albuquerque, New Mexico

Circle No. 288 on Reader Service Card in Product Review Section

- MISSILE AND AIRCRAFT  
TELEMETERING
- MISSILE AND DRONE  
GUIDANCE
- DATA ACQUISITION AND  
HANDLING SYSTEMS
- SYSTEMS DESIGN AND  
MANAGEMENT
- ENVIRONMENTAL TEST  
FACILITIES
- COMPUTING SYSTEMS
- COMMUNICATIONS



Mission of U.S. Air Force XQ-4 supersonic drone: ACT AS MISSILE TARGET  
Air-launched and recovered by parachute, the XQ-4 was developed by Radioplane, a division of Northrop Aircraft, Inc., to test U.S. air defense systems.



## NEW SUPERSONIC TARGET DRONE BY RADIOPLANE... LIQUID-COOLED WITH COOLANOL\* 45

\*Coolanol: Monsanto Trade Name

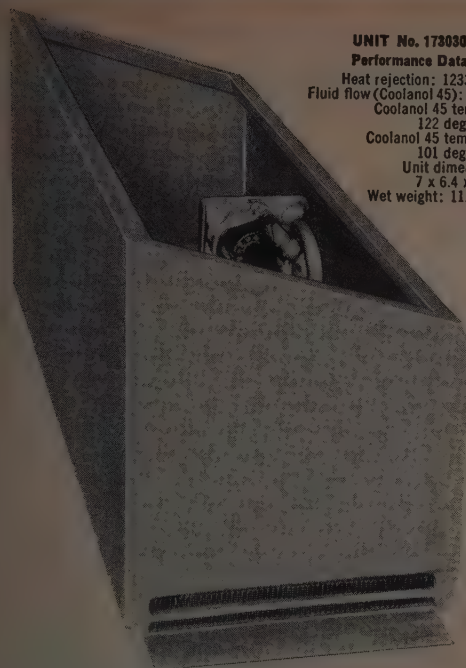
## AiResearch uses Coolanol 45 for increased

Liquid cooling with Coolanol 45 keeps temperatures within critical operating limits to assure reliable function of electronic equipment. Coolanol 45 is a coolant-dielectric liquid... operable from -65°F. to 400°F. Pumped around tubes

and other jacketed components, it sorbs heat... carries it from sensitive areas to be dissipated in the heat exchanger.

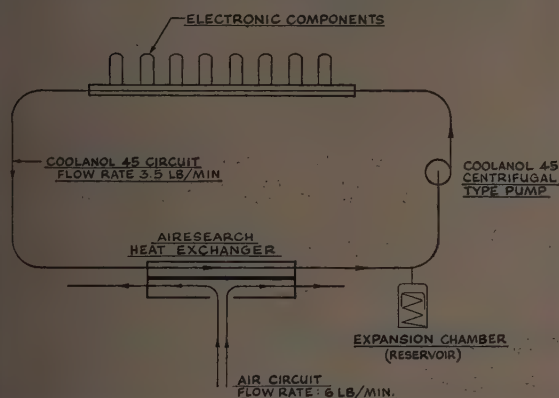
Coolanol 45 is versatile... operates as a hydraulic fluid as well as a coolant. One fluid "package" you can satisfy by





**UNIT No. 173030**  
**Performance Data**  
 Heat rejection: 1233 watts  
 Fluid flow (Coolanol 45): .5 GPM  
 Coolanol 45 temp. in:  
 122 degrees C.  
 Coolanol 45 temp. out:  
 101 degrees C.  
 Unit dimensions:  
 7 x 6.4 x 20 in.  
 Wet weight: 11.63 lbs.

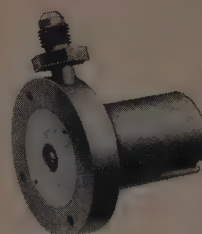
Coolanol 45 dissipates heat from electronic components of the XQ-4 through this liquid-cooling system (above) designed by The Garrett Corporation, AiResearch Manufacturing Division. System utilizes liquid cooling with Coolanol 45, forced air and cold plate as shown in the diagram.



**AiResearch uses Coolanol 45 in all these missile cooling components to assure precise temperature control of electronic equipment ... a key factor in missile reliability.**

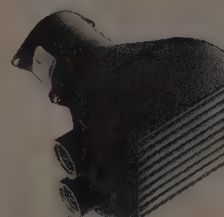
**MINIATURE CENTRIFUGAL PUMP**  
**Performance Data**

Operating temperatures:  
 65 degrees to 275 degrees F.  
 Fluid flow (Coolanol 45):  
 0.5 GPM at 10 psig. and  
 160 degrees F.  
 Motor: 10,000 rpm, 3-phase,  
 400-cycle ac (1 1/2 inches)  
 Net weight: Less than 1 lb.



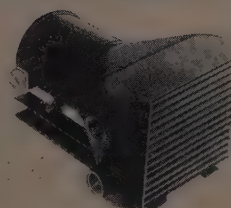
**UNIT No. 172010**  
**Performance Data**

Heat rejection:  
 2 kw at 15,000 ft. under the  
 following conditions:  
 Ambient air: 50 degrees C.  
 Fluid flow (Coolanol 45): 2 GPM  
 Fluid temp. in: 117 degrees C.  
 (Max. system temp.)  
 Envelope dimensions:  
 8.2 x 6.8 x 4.12 in.  
 Wet weight: 3.81 lbs.



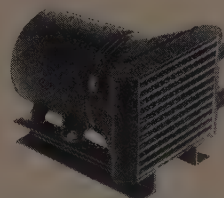
**UNIT No. 172030**  
**Performance Data**

Heat rejection:  
 10 kw at 5000 ft. under  
 following conditions:  
 Ambient air: 53 degrees C.  
 Fluid flow (Coolanol 45): 5 GPM  
 Fluid temp. in: 135 degrees C.  
 (Max. system temp.)  
 Envelope dimensions:  
 11 x 9.06 x 6.34 in.  
 Wet weight: 9.48 lbs.



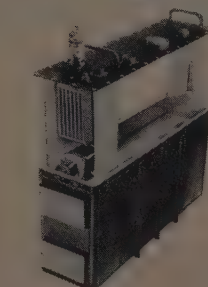
**UNIT No. 172040**  
**Performance Data**

Heat rejection:  
 2 kw at 60,000 ft. under  
 following conditions:  
 Ambient air: 22 degrees C.  
 Fluid flow (Coolanol 45): 1 GPM  
 Fluid temp. in: 147 degrees C.  
 (Max. system temp.)  
 Envelope dimensions:  
 7.5 x 8.5 x 6.6 in.  
 Wet weight: 9.06 lbs.



**UNIT No. 171600**  
**Performance Data**

Heat rejection: 175 watts  
 Fluid flow (Coolanol 45):  
 1.5 GPM  
 Fluid temp. in: 50 degrees C.  
 (Max. system temp.)  
 Compartment temp.:  
 63 degrees C.  
 Unit dimensions: 13x24x6 in.



**ELECTRONICS INTELLIGENCE**

IMPROVED Sidewinder guidance unit is being worked on by Motorola's Military Electronic Div. under a \$1,086,000 BuOrd contract.

**Pan Am places first airline Doppler order with Canadian Marconi**

SIX Doppler radars were bought by Pan Am from Canadian Marconi. This is the first purchase of a Doppler by an airline.

PAA bought the FM-CW sets for its Boeing 707-120 jetliners. The set doesn't meet Aric Characteristic 540-C-M and U.S. manufacturers don't expect to have sets that do until 3-6 months from now.

WHETHER this order offers a clue to PAA's or the other airlines' plans for the future is questionable. C-M in any case got the jump on U.S. manufacturers.

Competition for the Doppler radar sensor market—put at 1700 units for domestic and international airlines combined—is expected to be fierce.

SPERRY system built around a traveling-wave tube makes small test drones look like giant attacking bombers to ground radar systems. New "echo enhancer" was used successfully in recent flight tests at Cape Canaveral that involved the Sage air defense network.

The TWT package detects a ground radar pulse and sends back a greatly intensified signal. It has worked well at Mach 2 and altitudes over 50,000 ft. It can be widely used with either surveillance, air intercept, or tracking radars. It also enables ATC ground controllers to pick up and identify aircraft with greater certainty and at greater distances.

# Reliability in missile cooling systems

...cooling and power transmission. can eliminate the variables of multi- fluids and fluid systems by standard- on Coolanol 45. For complete techni- ata, write today for Technical Bul- AV-3 on Coolanol 45.



**MONSANTO CHEMICAL COMPANY**  
 Aviation Fluids Dept. AV-7  
 St. Louis 24, Missouri

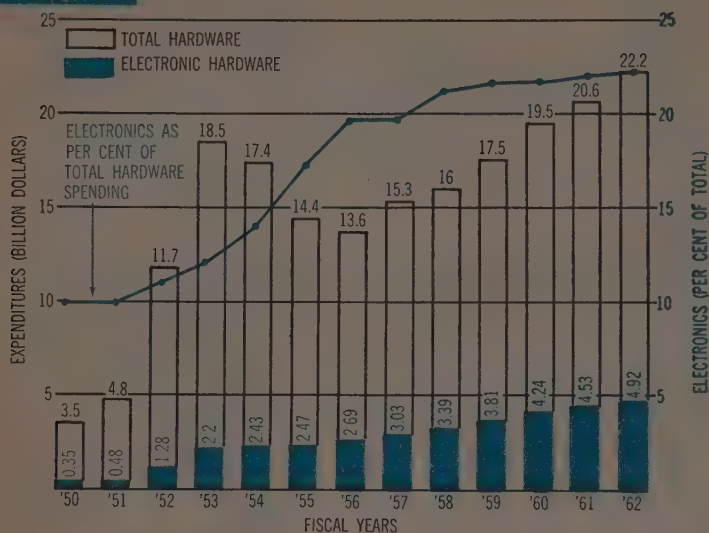
• When you need a synthetic fluid, come to Monsanto—creator of fluids for the future.





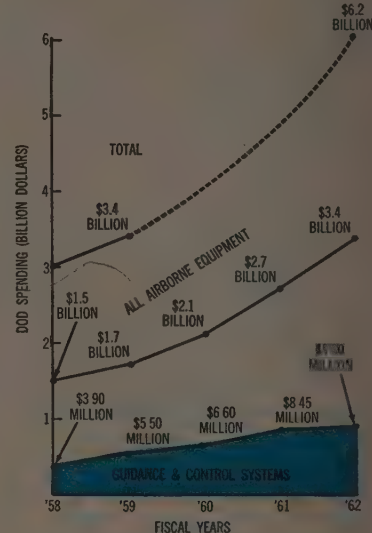
## Special Report

### Space/Aero Electronics



**ELECTRONICS'** share of Defense Dept. hardware spending (left) has gradually increased from 10 per cent of total in fiscal 1950, should hit 22.2 per cent in fiscal 1962. Despite this rise, space/aero electronics remains a buyer's market, with specially fierce competition for prime contracts. Research and development spending (not shown) is hard to determine accurately, since funds for it are drawn from

DOD's production and procurement accounts as well as from R&D accounts. Right: Guidance and control system costs in relation to other DOD missile expenditures. Spending on airborne equipment is expected to rise once the emphasis is switched from R&D to production, initial outlays are made on GSE, etc. All figures are estimates, except for fiscal 1958 and 1959 guidance and control system costs.



# Electronics outlook

## is bright in changing market

- **AIRCRAFT:** Military market shrinking, civil market expanding
- **MISSILES:** Electronics share to increase on all types except air-to-air
- **SPACECRAFT:** Little immediate effect on total market but potential is vast

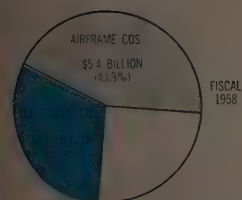
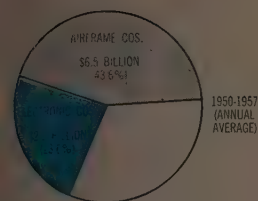
by **James Holahan**, Electronics Editor

**T**HE military will spend more on electronics in 1959 than in any past year, yet electronics will be a buyer's market. There will be no dearth of top industry talent competing for the some \$3.3 billion to be spent by the Defense Dept. on aircraft, missile, and spacecraft electronics.

Competition will be particularly fierce for prime system contracts. Under the weapons

system approach, the practice has been to award the prime to a firm with either a strong airframe or a strong electronics background and with systems management capabilities. Now, as the industry moves more rapidly from manned to unmanned combat vehicles, the airframe background is becoming less of a factor. The military has been stressing electronic skills combined with





PRIME contract awards (left) to 45 electronics and 28 airframe companies (including suppliers). Electronics category includes firms making propulsion units as well (such as GE and Westinghouse). Pie chart at top covers the period from July 1, 1950, to Dec. 31, 1957. Center: Military spending for airborne electronics (estimated for 1963 and 1968 in 1958 dollars). Figures exclude all ground equipment (even

systems engineering capabilities.

Except for certain special skill areas, the difference between airframe and electronic companies in technical competence for missile-making is shrinking more and more. Among major firms, both types have hired and otherwise acquired the other's skill.

All this adds up to the fact that the military has more system primes to choose from. Nevertheless, observers don't expect any drastic change in the near future in the practice of giving electronic companies only the primes on the smaller birds.

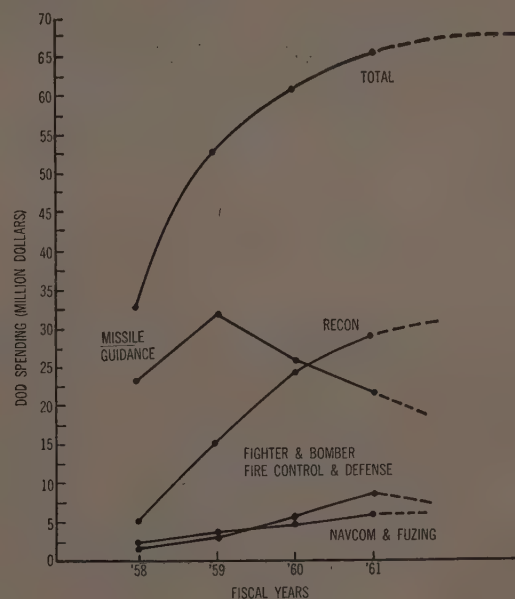
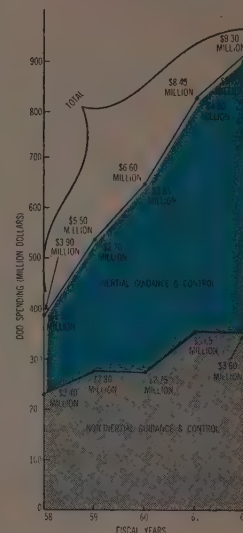
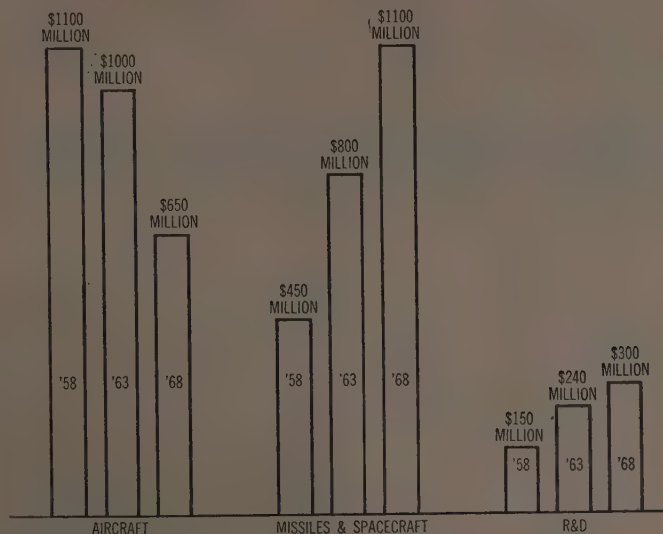
Team bidding, started only a year ago by medium-sized firms determined not to be shut out of large contracts, is having a profound effect on the industry. "Government-sponsored trusts" of large and small

firms alike are being set up to compete for major contracts and subcontracts for which a variety of skills and facilities and large amounts of money are needed.

One disadvantage of the team system is that certain coalitions may be formed that may make it harder for the fellow who was not asked to join to sell his "better mousetrap" or technical skill to the military. Some electronic companies also fear the team system might provide channels through which much of their proprietary information might leak to competitors.

The military—especially AF—today doesn't have the in-house competence for the proper technical evaluation of large projects. Therefore the military is putting more stress on the past experience and present competence of a bid-

command guidance radars, ground portions of data links, etc.), assume cold war situation continues as at present and DOD budget increases gradually. Marketing analysts at major electronics company who computed this forecast believe it's accurate within  $\pm 10$  per cent. Right: Trend to inertial guidance for missiles is shown by the results of a poll of missile and guidance system manufacturers.



MILITARY infrared market, industry survey shows, should climb to some \$70 million a year by '61 and then level off. Hopes are high for recon and surveillance applications, especially at very high altitudes and in space. IR guidance should peak in '59 and then fall off—because of shrinking role of manned interceptors with their air-to-air missiles, many of which are IR-guided. Civil market for IR, the survey showed, should amount to about \$5 million annually for the next 10 years.





## State of the art:

# Inertial guidance

- Electrostatic suspension
- Gas-lubricated and nuclear spin bearings
- Applied cryogenics

by **W. G. Wing**, Head, Engineering Dept.-Inertial Guidance, Sperry Gyroscope Co.\*

**T**HE progress of inertial guidance (IG) is paced by the development of the components, mainly gyros and accelerometers. The engineering effort in this area is paying off in a wide variety of applica-

tions—Sperry, for instance, is working on IG hardware over a range from the B-58's primary bombing navigation system to the miniature X-15 platform and the ultra long time Sins system.

Gyros for inertial systems must be of high quality in all

but the crudest applications. Long missions demand very low drift rates—tough to get even under the best conditions. Ballistic missile guidance requires only moderate drift accuracy, but in a troublesome acceleration and vibration environment. What is needed, above all, for ballistic missiles is good isoelasticity (uniform rigidity in various directions).

Suspension techniques characterize the different types of inertial gyros. The commonest is liquid flotation (with some supplemental means of establishing axes of rotation). It gives extremely low friction levels and excellent resistance to shock and vibration. The density of the moving element is limited to that of the fluid, which keeps down angular momentum and structural rigidity. Also, you have to be especially careful in assembling floated units to avoid dirt and gas bubbles.

Hydrostatic bearings using a compressed gas have been applied for some time. With careful design and fabrication, these can give very low uncertainty torques. Generally, gas bearings don't restrict the density of the moving element,

hence give high angular momentum with structural rigidity. The main drawbacks of this suspension are:

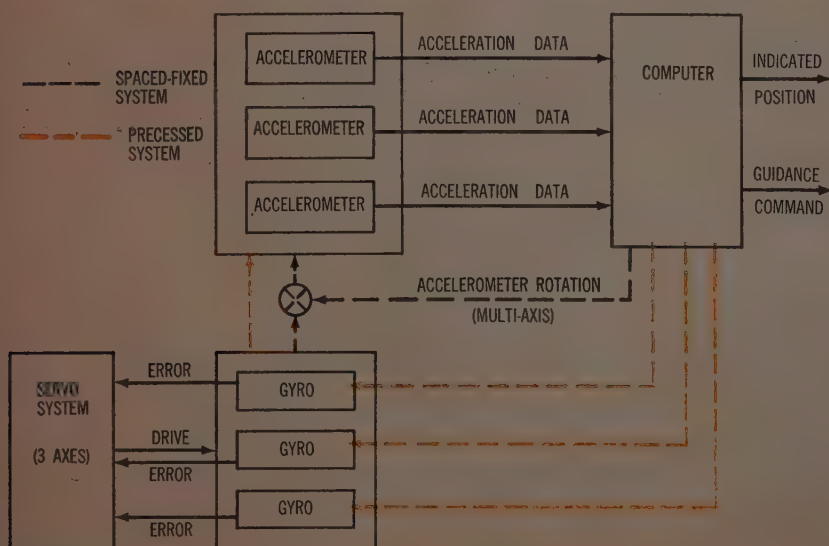
- high tolerances on parts,
- the need for a continuous gas supply,
- the need for absolute cleanliness to keep foreign particles out of the small gaps.

### Ball bearings for less critical uses

The old standby of the control gyro field, the ball bearing suspension, is virtually unknown in inertial guidance. One recent design, Sperry's Rotorace\* shows promise for the less critical areas (see *AvAge*, "Non-Floated 'Table' Nears Inertial Accuracy," June '58, p. 128).

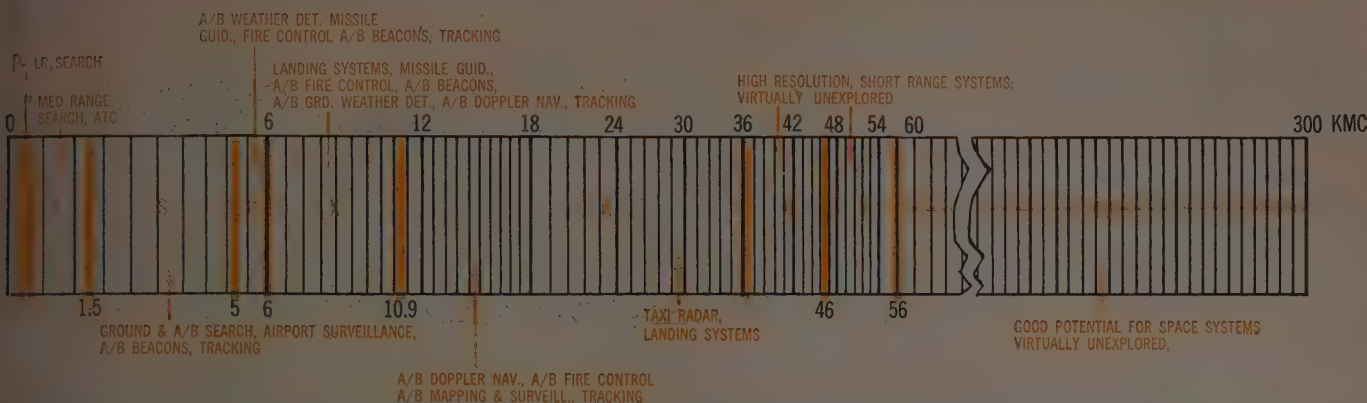
Both single- and two-degree-of-freedom gyros are used. The single-degree-of-freedom gyro needs extreme mass-balance accuracy about only one axis and good isoelasticity in only one plane. On the minus side, it allows significant disturbances in the orientation of the spin vector under angular vibration. This leads to drift error. Moreover, you need

\*Registered trademark.  
more on page 82



**SPACE-FIXED AND PRECESSIONED** gyro guidance systems. Space-fixed method of getting directional reference is well suited to ballistic missile needs. Limiting factor is gyros' susceptibility to time-varying direction of gravity, which leads to appreciable drift rates. Principle of precession is to rotate the entire reference element in a manner corresponding to the earth's. Gyro torquing accuracies are critical here.





**SPECTRUM** for aircraft, missile, and spacecraft radar extends from P-band to MM region. Far end of spectrum is virtually unexplored, has great potential. As interference problems among "friendly" radars are becoming acute, at least some semi-rigid control is expected.

# State of the art: Radar

- High power microwave amps and components
- Statistical design concepts
- Low noise UHF and microwave components

by James Holahan, Electronics Editor

**PERFORMANCE** gains in post-Korea radars have come at the expense of an inordinate amount of R&D and engineering. Now, thanks mainly to three developmental "dents" (if not break-throughs), there should be a bigger performance payoff on future efforts. These "dents" are:

- availability of high power microwave amplifiers and associated components,

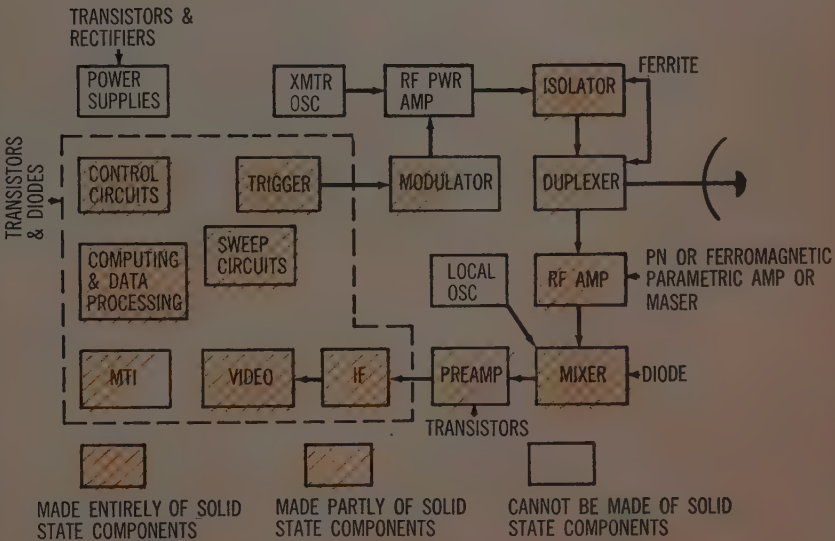
- development of statistical design concepts,
  - availability of low noise UHF and microwave components.
- The basic task of any radar is to detect its target and to discriminate against other targets and natural and man-made decoys. Both detection and discrimination depend very largely on the amount of returned energy.

Inevitably, any return carries noise. The basic requirement for a workable signal therefore is that the ratio of received energy to noise per unit bandwidth ( $E/N_0$ ) be sufficient for the signal to be resolved in range, azimuth, or

waveform (depending on the particular system). Obviously, the most direct way of insuring a workable  $E/N_0$  is to put more energy on the target. This means higher radiated energy per de-

more on page 94

**"SOLID STATE"** radar progress. Use of transistors, diodes, and ferrites in future radars will mean smaller, lighter, cooler, more efficient, and more reliable equipment. In several radars, a few of the "building blocks" have been transistorized. Within a few years, we can expect to see many radars "solidified" at least to the extent shown here.

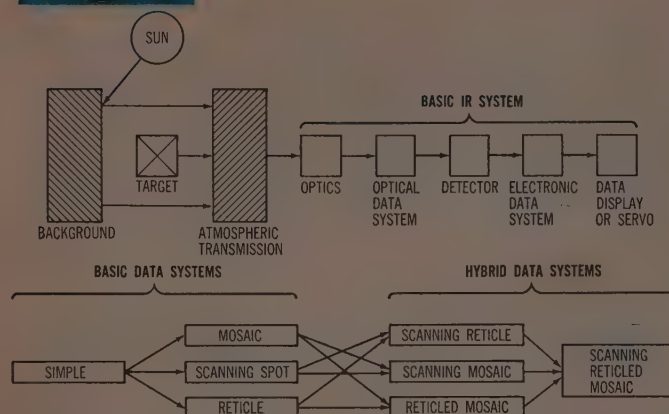




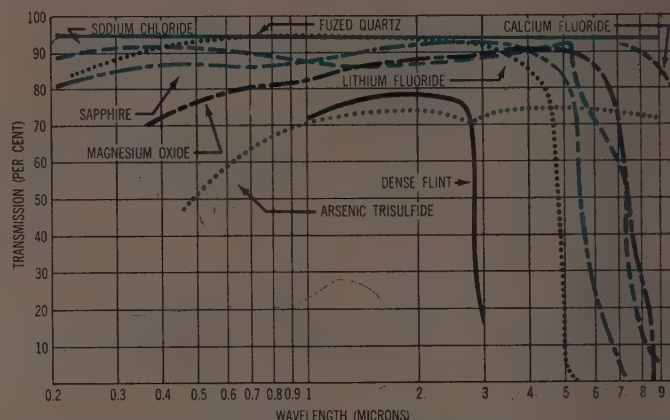


## Special Report

### Space/Aero Electronics



**BASIC** infrared design (left): Block diagram of typical IR system (top) applies equally to search, track, and dual-mode use. Main differences between these applications lie in the data unit. Bottom:



Eight possible versions of the data unit. Right: Optical transmission characteristics of some typical infrared materials. The most sensitive detectors must be operated well below ambient temperatures.

## State of the art: Infrared

- Rapid-scan detectors for better recon
- Use of thermopause region of spectrum
- Needed: Adequate radiation data

by **Raymond H. McFee**, Director of Research  
Avionics Div., Aerojet-General Corp.\*

**T**HE recent success of infrared-guided missiles in the Quemoy area conclusively proved infrared (IR) design has reached operational capability. For IR equipment, this capability hinges on two factors: (1) adequate supply of special components and (2)

\*Aerojet-General Corp., Azusa, Calif.

effective detection and information processing techniques.

Generally, IR system design has two major requirements:

- The system must be able to determine angular location and other characteristics of targets of interest accurately and reliably—even though other sources of IR radiation,

not of interest to the system, may be present.

● The data received by the system must be in such a form that they can be acted on (either instantaneously and automatically or after interpretation).

IR devices use optical, electronic, and photoelectric methods to get their information. Since they operate chiefly in the wavelength region of the electromagnetic spectrum between 1 and 15 microns ( $10^{-4}$  to  $1.5 \times 10^{-3}$  cm), angular resolution limits due to diffraction effects are relatively minor.

By the same token, the mechanical tolerances of the energy-gathering devices are cor-

respondingly more severe than in longer wavelength equipment. However, since optical techniques can be used in this spectral region, the necessary precision is easily obtained.

### Trend points to use of 3-5-micron region

The trend in current IR system design is primarily toward use of the thermopause region of the spectrum (3-5 microns). Some consideration is also being given to the thermal region (8-14 microns). The interest in these regions is the result of the increasing availability of long-wavelength detectors and optical materials.

more on page 88





When control means  
reliable performance...

For every basic airborne system—fuel, pneumatic, hydraulic, mechanical, electrical, and electronic—Hydro-Aire's reputation and know-how guarantees a reliable answer to your control problem. Among these answers: the Hytrol anti-skid braking system, Hy-v/l fuel pumps, all types of pneumatic and fuel valves, actuation packages, fractional h.p. motors. Many others... more in the future.

Producing Controls for every Basic Airborne System

**HYDRO-AIRE**

BURBANK, CALIFORNIA

Aviation Subsidiary of CRANE

Anti-Skid Braking Systems • Fuel

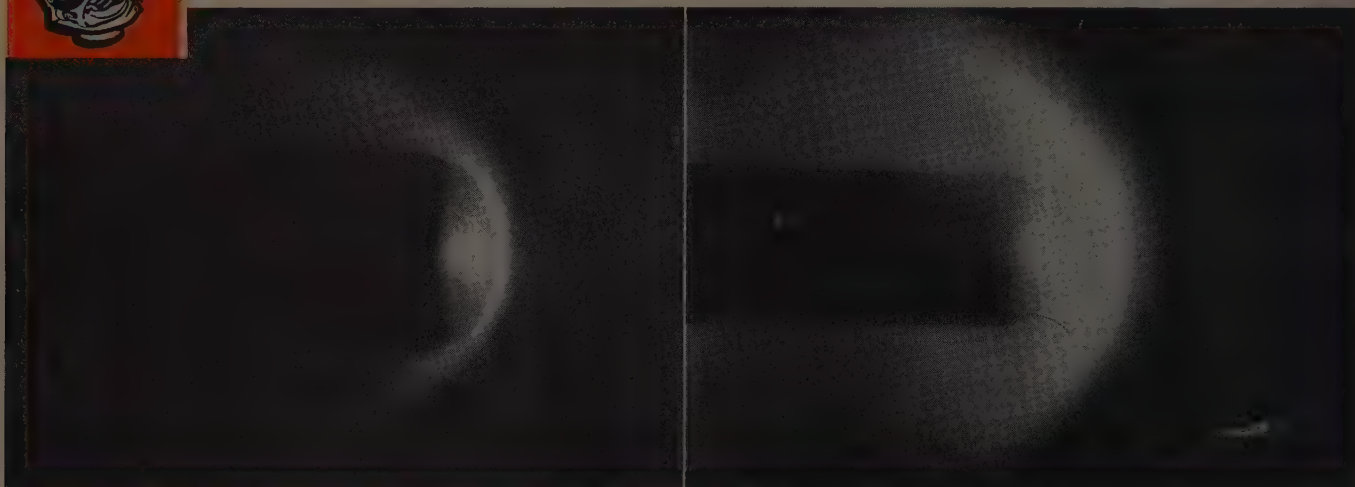
System Controls • Pneumatic

Controls • Actuation Systems

Electronic Devices

Circle No. 5 on  
Reader Service Card  
in Product Review  
Section





**FIGURE 1:** Detached shock waves can be obtained with magnetohydrodynamics, STL studies show. Probe containing magnetohydrodynamic device was inserted into very high speed gas flow. Before and after

shots show that, after the device is turned on, the magnetic field pushes the gas off the probe's critical areas by changing its density. This might be used to prevent overheating of re-entry surfaces.

# Magnetohydrodynamics

## opens up new electronic vistas

The new science of magnetohydrodynamics, or the interaction of electric effects and fluid flow, is paving the way for important advances in both basic electronics and overall vehicle design. Applications already under study include magnetic fields as the propulsive force for space craft and microwave amplification.

by Irwin Stambler, Engineering Editor

**M**AGNETOHYDRODYNAMICS (MHD) is the combining form of the previously separate disciplines of electrodynamics and hydrodynamics. The former has to do with the complete study of electricity, magnetism, and their combinations, from propagation phenomena to MHD. Another way of defining electrodynamics, Dr. Milton Clauser, of Space Technology Labs (STL), told SPACE/AERONAUTICS, is that it deals with any phenomena described by Max-

well's equations. Hydrodynamics, of course, deals with all kinds of fluid motions.

If the fluid becomes a conductor, the two disciplines are united. MHD is thus defined as the study of the interaction of magnetic fields with electrically conducting fluids.

"Magnetoaerodynamics" is sometimes used interchangeably with MHD. However, Dr. Clauser points out, the former stresses with cases for which compression and changes in density are important, which



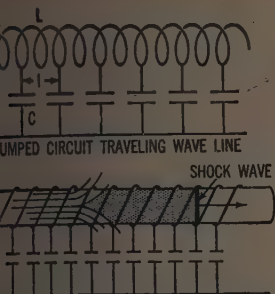


FIGURE 2: Electromagnetically driven shock tubes can provide speeds of propelling gases at speeds of over Mach 100. One example, suggested by Dr. Milton Clauser of STL, uses lumped parameter electric circuits, which produce traveling magnetic fields (bottom) for driving shock waves. The speed is  $1/\sqrt{LC}$ , where  $L$  is inductance per section and  $C$  is capacitance per section.

...lies gas phenomena. MHD is a more general term covering both incompressible and compressible fluids. There are electrically conductive liquids, Dr. Clauser explains, such as mercury and water, but it hasn't been possible to do much that is unusual with them. The situation is different with gases. In air at 2500 deg K and over, for example the thermal motion of the molecules is such that collisions occur in which the molecules dissociate into atoms. At about 4000 deg K, electrons begin to be knocked free. The gas becomes ionized and a good conductor. Conductivity rises rapidly with temperature. Dr. Clauser explains that, at the re-entry speeds of ballistic missiles, the gas becomes as good a conductor as carbon. Once a gas has this property, it can be heated by a magnetic field.

more on next page



## PIONEERS IN MOBILE MISSILE SYSTEMS

The "Sergeant's" excellent mobility characteristics, including the ability to operate under conditions of winter snow, ice, mud, desert sand and heat, significantly extend the capabilities of the system for close support of a ground command in our modern United States Army. The ease of operation and handling

permits the weapon to be unloaded from airplanes or landing craft and be ready for firing with a minimum of preparation.

The system concept demonstrated in the "Sergeant" has permitted excellent mobility and speed of operation to be attained. The requirements of the Army have been stressed, resulting in outstanding

characteristics of the weapon meriting the title of "America's first truly 'second generation' surface-to-surface tactical missile."

The responsibility for accomplishing this important achievement has been placed on JPL by the United States Army Ordnance Missile Command.



**JET PROPULSION LABORATORY**  
A DIVISION OF CALIFORNIA INSTITUTE OF TECHNOLOGY  
PASADENA • CALIFORNIA

OPPORTUNITIES NOW OPEN  
IN THESE CLASSIFICATIONS

APPLIED MATHEMATICIANS • ENGINEERING PHYSICISTS • COMPUTER ANALYSTS • IBM-704 PROGRAMMERS  
FIELD ELECTRONIC ENGINEERS • SENIOR R.F. DESIGN ENGINEERS • STRUCTURES AND DEVELOPMENT ENGINEERS





Basic KX4 Switch

## KLIXON Precision Switches

*Help Hughes Aircraft Corp. Obtain Maximum Reliability in Falcon Launchers*

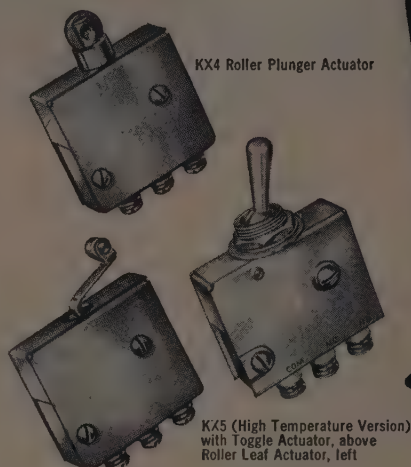
A vital weapon in the arsenal of the U. S. Air Force is the Hughes Falcon air-to-air missile. And in the Falcon Launchers, as in other armament control systems, guided missiles and operational aircraft, KLIXON Precision KX4 Switches play an important role in assuring dependability of operation.

These KLIXON Switches, manufactured to exacting tolerances, are used in Falcon Launchers to indicate proper loading and firing of the missiles.

KLIXON Precision Switches are ideal for applications of this type. They are enclosed in a strong steel case capable of withstanding heavy impact and compression loads. True hermetic sealing is achieved with a metal "wave type" diaphragm at the actuating lever providing precision switching unaffected by environmental conditions. They are fully approved under MS 24456-1 (USAF).

The KLIXON KX4 Hermetic Switch is rated for 10 amperes, resistive, at 115 VAC and 30 VDC with life expectancy far in excess of specification requirements. A higher temperature version of the KX4 (KX5) is also available.

Many types of standard actuators are available. Or, to meet the particular requirements of your application, we'll be pleased to design a special package. Write for our precision switch catalog.



KX4 Roller Plunger Actuator

KX5 (High Temperature Version) with Toggle Actuator, above  
Roller Leaf Actuator, left

**METALS & CONTROLS**

Spencer Division



**KLIXON**

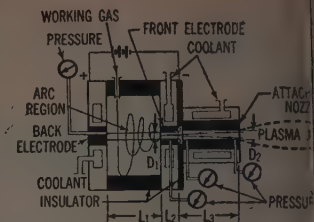
**CORPORATION**

3701 Forest Street, Attleboro, Mass.

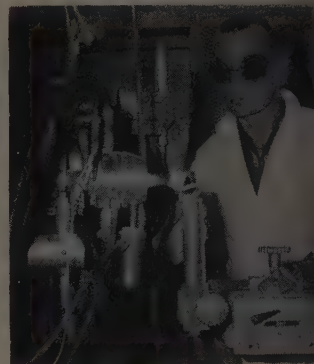
Western Manufacturers — refer inquiries directly to Metals & Controls Corporation, Southern California Office . . . 232 North Lake Avenue, Pasadena, California . . . Telephone: Ryan 1-4288.

Circle No. 6 on Reader Service Card in Product Review Section

## MAGNETOHYDRODYNAMICS



**FIGURE 3:** Plasma generator used in MHD research by Gianni Plasmadyne.



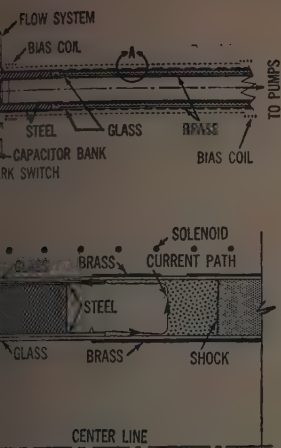
**PLASMATRONS** developed by Gianni Plasmadyne are already finding commercial and test use. This unit is used for high temperature materials studies and for flame-spraying of ceramic coatings.

One of the major areas of current MHD work is the development of magnetic power plants for spacecraft. This is based on the acceleration of a stream of ionized gases, or plasma, by electric means.

One approach, taken by such firms as Gianni Plasmadyne, is referred to as thermal plasma propulsion. It uses electric arc methods involving Joule heating with and without electrodes—to provide hot gases with specific impulses between 300 and 3000 seconds. A typical plasma generator consists of a cylindrical chamber with a cylindrical electrode at the back and an annular one at the front (Fig. 3).

In operation, a power supply establishes a potential between the front and back electrodes and maintains an arc between them. The working gas passes through the arc and out the orifice, being heated





**VIEW A**  
ACCELERATION of fully ionized plasma to propel spacecraft has been suggested by such firms as General Electric, which has designed this magnetic test accelerator. View A shows detail of accelerator's breakdown region.

ionized in the process. Because the gas has a high exit velocity, it imposes a great deal of thrust on the chamber.

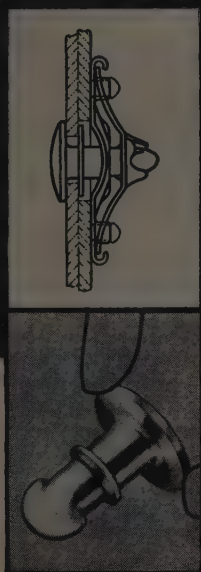
Another approach, called magneto-plasma propulsion, makes use of strong pulsed electromagnetic fields to ionize and accelerate gases. Specific pulses from 3000 seconds on up can be obtained. A great many organizations are working in this area, including General Electric, GE, Giannini Plasma, and STL.

A typical design of this type makes use of a long tube to which are attached a series of condensers (Fig. 2). The set-up is similar to that of a traveling wave tube. A solenoid is installed around the tube. The propellant starts to enter the tube through a valve, electrodes are fired that produce enough electric discharge to ionize a small amount of propellant. The magnetic current from the solenoid induces a current in the gas. This current repels the current in the coil, and, since the coil can't move, the gas does.

The condensers are fired  
*more on next page*

# Criteria of Reliability...

## BOEING 707 Jet Stratoliners



## use LION Quarter-turn FASTENERS

The demands of today's airborne requirements are met by Lion Quarter-turn Fasteners. They are accepted as standard throughout the aircraft industry. They are completely reliable... stand up under the most rugged conditions of shear, vibration and tension.

Smooth positive action is assured by the swaged-nose stud on Lion Quarter-turn Fasteners. There are no milled sections, inserts or cross pins; no potential points of failure. No wire spring is required to hold the Fastener in locked position.

One-quarter turn locks the Fastener... one-quarter turn opens it. Six head styles and two sizes available. Lion Aviation Fasteners meet MIL-F-5591A (ASG) requirements and are CAA approved.

WRITE TODAY FOR FREE COPY OF  
**SOUTHCO FASTENER HANDBOOK**

Contains complete engineering data on Lion Quarter-turn Fasteners and many other special Fasteners. Write to:  
**SOUTHCO DIVISION**, South Chester Corporation, 253 Industrial Highway, Lester, Pa.



©1959



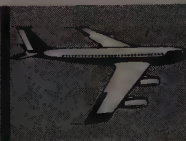
MISSILES



CIVILIAN



MILITARY



COMMERCIAL

# LION *Aviation* FASTENERS

one of the



Circle No. 7 on Reader Service Card in Product Review Section



All the right connections for



## AMAZING PERFORMANCE

The hand can be quicker than the eye with Deutsch DM9700 series miniature push-pull plugs. These master performers, with the exclusive Deutsch ball-lock coupling ring, simply push-in for positive lock and seal... pull-back for instant disconnect.

Deutsch miniature plugs take the guesswork out of your application. Like magic, they withstand temperature extremes of from  $-67^{\circ}$  to  $250^{\circ}$  F.; physical shocks up to 100 G's; and are unaffected by altitude pressure variations.

Inside the DM9700 shell is the secret:

Voltage Rating . . . Flashover 2,500 V DC and  
2,000 V @ 60 CPS (AC-RMS)  
Current . . . . . 7.5 amps @ 2 volts AC  
Contact Resistance 9.7 millivolts @ 7.5 amps  
Meets or exceeds requirements of MIL-C 5015C

Electrical wizards can get the inside information on these 3, 7, 12, 19, 27, 37, and 61 contact Deutsch miniature plugs—and their stellar partners, the DM9600 series miniature push-pull receptacles and DM5600 series miniature hermetic receptacles—just as quick as a wink.

Ask for data file 1E and presto, you'll have it.

**The Deutsch Company**

7000 Avalon Boulevard • Los Angeles 3, Calif.



© 1969, THE DEUTSCH COMPANY

## MAGNETOHYDRODYNAMICS . .

one after the other to help push the gas out the tube. In the process, a shock wave develops that ionizes the rest of the gas. Continued "squeezing" ionizes the gas ahead of the tube to make it a good conductor. Thus when a current is induced in the gas, the whole slug of gas is moved out of the tube at very high speeds.

These MHD powerplants have low thrust-weight ratios and so wouldn't be good for such functions as takeoff from earth for which high thrust is needed. For space flight, though, where small accelerations over a long period are needed, they are very promising.

### Re-entry drag brakes are being studied

The fact that gas around a re-entry body is heated and ionized to the point where it becomes a good conductor pinpoints another possible use for MHD. In this regime, magnetic fields can be used to control the flow around a body and also to influence the heat transfer rates.

In detached shock studies, STL has inserted a probe containing a 40-turn solenoid into very hot and ionized gas (Fig. 1). When the coil is activated, a voltage is generated in the gas that produces a current flow. The interaction between this current and that of the magnetic field displaces the shock from the nose of the probe body. The magnetic lines of force are bent back along the body.

One of the basic limitations in MHD is magnet materials. The stress imposed on coils by a magnetic flux of 5000 gauss is about 15 psi. Magnets have been built that provide about a million gauss for short periods—but the result is a tensile stress in the coils of 600,000 psi, and practically no material is available to take this. Copper, for instance, is good to 250,000 gauss, and beryllium copper yields at 750,000 gauss.

## EXTREME TEMPERATURE ELASTOMERS

### Silicone Rubber at $800^{\circ}$ F

We have recently run tests to determine the effect of dry heat aging silicone rubber at  $600^{\circ}$  F,  $700^{\circ}$  F and  $800^{\circ}$  F. The purpose of these tests, both to establish the upper time/temperature limits of commercial compounds regarded as high temperature compounds and to pinpoint the problems of compounding silicone rubber for extreme temperature use.

Using 50% at the lowest ultimate elongation at which a rubber is considered useful, the life of the best compound was found to be about 72 hours at  $600^{\circ}$  F, 2 hours at  $700^{\circ}$  F and five minutes at  $800^{\circ}$  F.

In compounding the rubber, selection and quantity of catalysts and fillers used appeared to be quite critical in high temperature breakdown. Highly reactive, quick vulcanizing type gums requiring little catalyst showed better high temperature resistance in our tests than less reactive types requiring more catalyst. Varying the fillers produced different breakdown temperatures.

Based on the information gained in these tests, we are carrying out a compounding research program to improve the high temperature resistance of silicone rubber. The results will be published as soon as available.

**Conclusion:** With proper attention to compounding, silicone rubber still provides better extreme temperature flexibility than any other elastomer. Though disappointing at  $800^{\circ}$  F, the same compounds tested will withstand  $500^{\circ}$  F for month or more,  $700^{\circ}$  F for several hours. They will also remain flexible in the  $-65^{\circ}$  F to  $130^{\circ}$  F range and provide shelf life of many years.

Copies of the tabulated results of our high temperature tests are available for the asking. Write The Connecticut Hard Rubber Co., 407 East Street, New Haven 9, Connecticut.

## CONNECTICUT HARD RUBBER

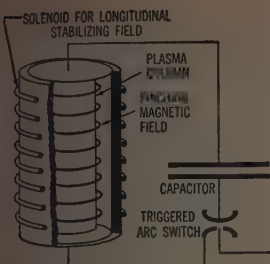
THE CONNECTICUT HARD RUBBER CO.  
NEW HAVEN 9 CONNECTICUT



 AIRFRAME SCALES	 ELASTOMER RESEARCH	 SILICONE RUBBER DUCTS
 PRESSURE SENSITIVE REGIONS & SILICONE RUBBER TAPE	 SILICONE RUBBER SHEETS, HOLDINGS & EXTRUSIONS	 SILICONE RUBBER COATED FABRICS & FABRICATED PARTS

Circle No. 9 on Reader-Service Card  
SPACE/AERONAUT





**FORCE EFFECT** is important in magnetohydrodynamic work. Pinching of magnetic field compresses hot plasma and keeps it away from chamber walls. One of the devices used for pinching this linear discharge tube.

One group working on this problem is that of Dr. Ralph Waniek, at Giannini Plasma-lab. To extend the range of conventional types of magnets, he told SPACE/AERONAUTICS, his group is studying designs using tungsten alloys especially created for high gauss work. These have high conductivity and tensile strength. Some devices are operated in liquid nitrogen so that heating effects do not longer to destroy the coil. Waniek's group has designed a number of test devices; in one case  $2 \times 10^6$  gauss, or  $3 \times 10^6$  gauss was obtained in explosive geometry.

However, researchers have come up with an alternate method—"force-free" coils. If you have two parallel, infinite sheets, Dr. Waniek states, and separate current in each sheet, lines of force produced by these currents don't interact if they are at 90 deg to each other. They do, though, produce a net magnetic field in a certain direction.

Force-free geometry, Dr. Waniek notes, is complicated but not insoluble. Researchers have already developed successful test configurations. Like the high gauss designs, this approach can provide fields acting as "pistons" in accelerating gas to high speeds.

more on next page

Build Quality  
in Your Line  
with

**BISHOP  
TUBING  
AND  
PLATINUM  
PRODUCTS**

"Metals for Precision  
and Performance"



Quality begets quality—it's an established axiom that premium products must begin with quality components. BISHOP has been producing platinum and precious metal products since 1842 . . . precision stainless steel tubing since 1931. The BISHOP family of metal products includes a broad variety of components for the designer, engineer . . . just to mention a few:

**Capillary Tubing**—stainless grades, standard sizes up to .130" OD

**Platinum & Platinum Alloy Wire**—#50 to #3 B & S Gauge

**Clad Metals**—base and precious metals in various combinations

**Glass-To-Metal Sealing Alloys**—low expansion alloys

**Thermocouple Wire**—noble metal and noble metal alloys

**Tubing**—nickel, stainless, platinum, special alloys up to 1" OD

**Tubular Fabricated Parts**—all varieties—conventional forming operations

**Composite Wires**—base and precious metals in various combinations

**Platinum Contacts, Discs, Laboratory Apparatus**

**CATALOGS, DATA SHEETS SENT PROMPTLY ON REQUEST**

Begin your next design with *unexcelled* quality BISHOP component materials. Write, wire or phone Malvern 3100.



**J. BISHOP & CO.**

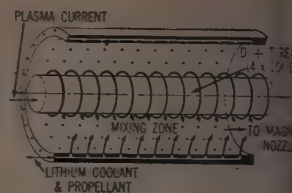
platinum works

MALVERN, PENNSYLVANIA



*Tubexperience in action*

MAGNETOHYDRODYNAMICS



**REACTION** chamber of fusion propulsion system suggested Dr. Clauser and Dr. Weibel STL. This system uses the pin effect to contain plasma that reaches temperatures on the order of  $4 \times 10^8$  deg K.

Looking further ahead, researchers believe that ionized gas can be made to attain force-free geometry, so that a magnet can eventually be made of gas instead of a solid.

Although originally studied because of its astronautic possibilities, MHD also shows promise for a wide range of other uses in fields ranging from metallurgy to electronics. For instance, the plasma jet first developed for research have already been applied to cut metals and for flame-spraying coating. Some researchers have suggested possible uses in microwave amplification.

Other studies are aimed at developing MHD generators and motors, to replace conventional power generation equipment, such as the steam turbine and the electric generator. In a conventional motor, for instance, inducing current in copper conductors results in magnetic forces that rotate the armature. In an MHD unit the copper is replaced by conducting fluid.

One obvious advantage of that moving parts are eliminated, which overcomes such problems as bearing performance, fatigue stress, etc. Much higher speeds should become possible. Another interesting aspect is that it wouldn't be necessary to retain the circular geometry of conventional units.

Still another application

SPACE/AERONAUTICS

FLASH!

SUPERIOR NOW PRODUCING  
TUBING IN OVER 20 NICKEL  
AND NICKEL ALLOY ANALYSES



A GOOD REASON FOR PREFERRING SUPERIOR

## *The big nickel tubing news of the year!*

**Superior is again producing nickel and nickel alloy tubing in quantity—even for non-priority orders**

\* Now you can get rid of substitute materials—and specify nickel and nickel alloy tubing again! Superior is producing premium quality tubing in more than 20 different nickel and nickel alloy analyses, and in many sizes, shapes and tempers. Raw stock deliveries to the mill are on the upswing and expected to keep increasing steadily.

The excellent corrosion resistance, high strength, workability, and many other valuable properties of these alloys are well known to designers and engineers on jet, missile and rocket

projects. The unusually high strength, heat and corrosion resistance of some of these analyses actually put them in the vital Super Alloy class. There can be no real substitute for tubing of this outstanding caliber—and the need for substitutes no longer exists. Nickels are back!

Superior also excels in the close tolerances and perfection of finished product so necessary to the aircraft industry. And our ample facilities and long experience are reinforced by a broad range of special tests and inspections you can request to assure maximum performance in the tubing you order.

For complete data on Superior nickel and nickel alloy tubing, send for a free copy of Catalog Section 12. Write Superior Tube Company, 2038 Germantown Ave., Norristown, Pa.

# *Superior Tube*

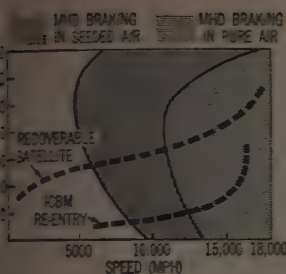
The big name in small tubing  
**NORRISTOWN, PA.**

All analyses .010 in. to  $\frac{3}{8}$  in. OD—certain analyses in light walls up to  $2\frac{1}{2}$  in. OD

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. • Raymond 3-1331

Circle No. 11 on Reader Service Card in Product Review Section





MAKING of very high speed vehicles by magnetohydrodynamics is being studied by Avco.



MAGNETOHYDRODYNAMIC methods are used by Giannini Plasdyne in this hyperthermal wind tunnel. Hot jets of ionized gases, or plasmas, simulate flight at very high Mach numbers and stagnation temperatures of 15,000 deg K.

MHD is in controlling fusion reactions. In fact, this may prove to be the most important of all MHD uses.

The fusion process is based on the fact that the collision of two light elements—particularly the isotopes of hydrogen—can result in their fusion to a heavier element with a release of energy. As Dr. Klaus states, the reaction rates don't become significant until the relative velocity is high enough to overcome the Coulomb repulsion of the charged particles and bring the nuclei together. This requires a speed of  $10^8$  m/sec, which corresponds to 100,000,000 deg K, or 10 kev.

Obviously, at such temperatures no reasonable volume of plasma can be in touch with any cold matter, or it would quench itself. The solution is to keep the plasma from touching the chamber walls by mag-

more on next page

# MISSILE IMPACT PREDICTION



## IN .0001 SECOND

**TRICE**, the world's most advanced computer, saves many minutes over time currently required for ballistic missile impact prediction. TRICE modules (Integrators, Multipliers, etc.) can be assembled as a special purpose computer for dynamic systems or as a digital differential analyzer. Its incredible speed of 100,000 iterations per second in parallel is unaffected by the size of the problem. The first model is in operation at the U.S. Army Ordnance Missile Command, Huntsville, Ala.

*Write for literature describing TRICE and its many uses: aerodynamic stability, control system stability, impact prediction, stable platform calculations, satellite orbit predictors and others.*

PACKARD-BELL COMPUTER CORP.

a subsidiary of

## PACKARD BELL ELECTRONICS

12333 W. Olympic Blvd.

Los Angeles 64, Calif. BR. 2-2171

### ENGINEERING BEYOND THE EXPECTED

TRICE (Transistorized Realtime Incremental Computer, Expandable) is the first computer to combine the accuracy and repeatability of a digital computer with the speed, flexibility and ease of programming of an analog computer.

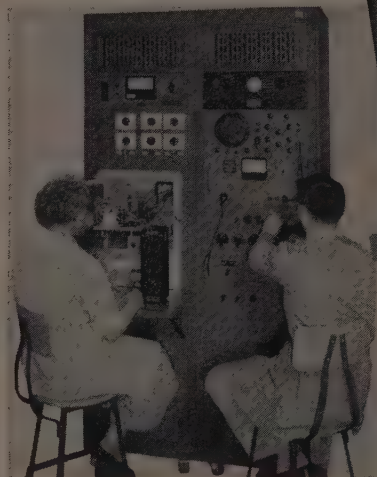


# Temperature Compensated PRECISION TACHOMETER

- .16% Linearity 0-3600 RPM
- .05% Output Voltage Tolerance at 3,000 RPM
- 2V per thousand RPM voltage gradient
- 15°C to 75°C temperature range
- 0° ± 6 minutes 3000 RPM phase shift
- 10 mv max. null voltage
- 3 mv max. in phase axis error
- 115V 400 cycle input, 8 watts
- Size 20 illustrated (Type 20TG-6777-01.) Other sizes with similar or greater accuracies can be designed to your requirements. Write or call your nearest Oster office for further information today.

**Oster**®

Precision Tachometer  
Production Testing



**actual size**  
Type 20TG-6777-01

Burton Browne Advertising

Other products include servos, synchros, resolvers, motor-gear-trains, AC drive motors, DC motors, servo mechanism assemblies, reference and tachometer generators, servo torque units, actuators and motor driven blower and fan assemblies.

**John Oster**

**MANUFACTURING CO.**  
Your Rotating Equipment Specialist  
Avionic Division  
Racine, Wisconsin

**NEW YORK  
OFFICE**

237 North Main Street  
Hempstead, L.I., New York  
Phone: IVanholer 3-4553  
TWX Hempstead N. Y. 705

**NEW JERSEY  
OFFICE**

517 Lyons Avenue  
Irvington, New Jersey  
Phone: Essex 1-2361

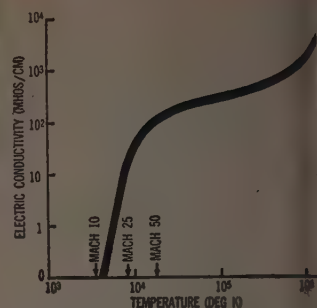
**WESTERN  
OFFICE**

5323 So. Sepulveda Blvd.  
Culver City, California  
Phone: EXmont 1-4742  
TEXAS 8-1194  
TWX 5, Men 7571

**Engineers For Advanced Projects:**

Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Robert Burns, Personnel Manager, in confidence.

## MAGNETOHYDRODYNAMICS



**CONDUCTIVITY** of air rises rapidly with increasing Mach number after dissociation begins (about Mach 12), STL graph shows.

netic or electrical force

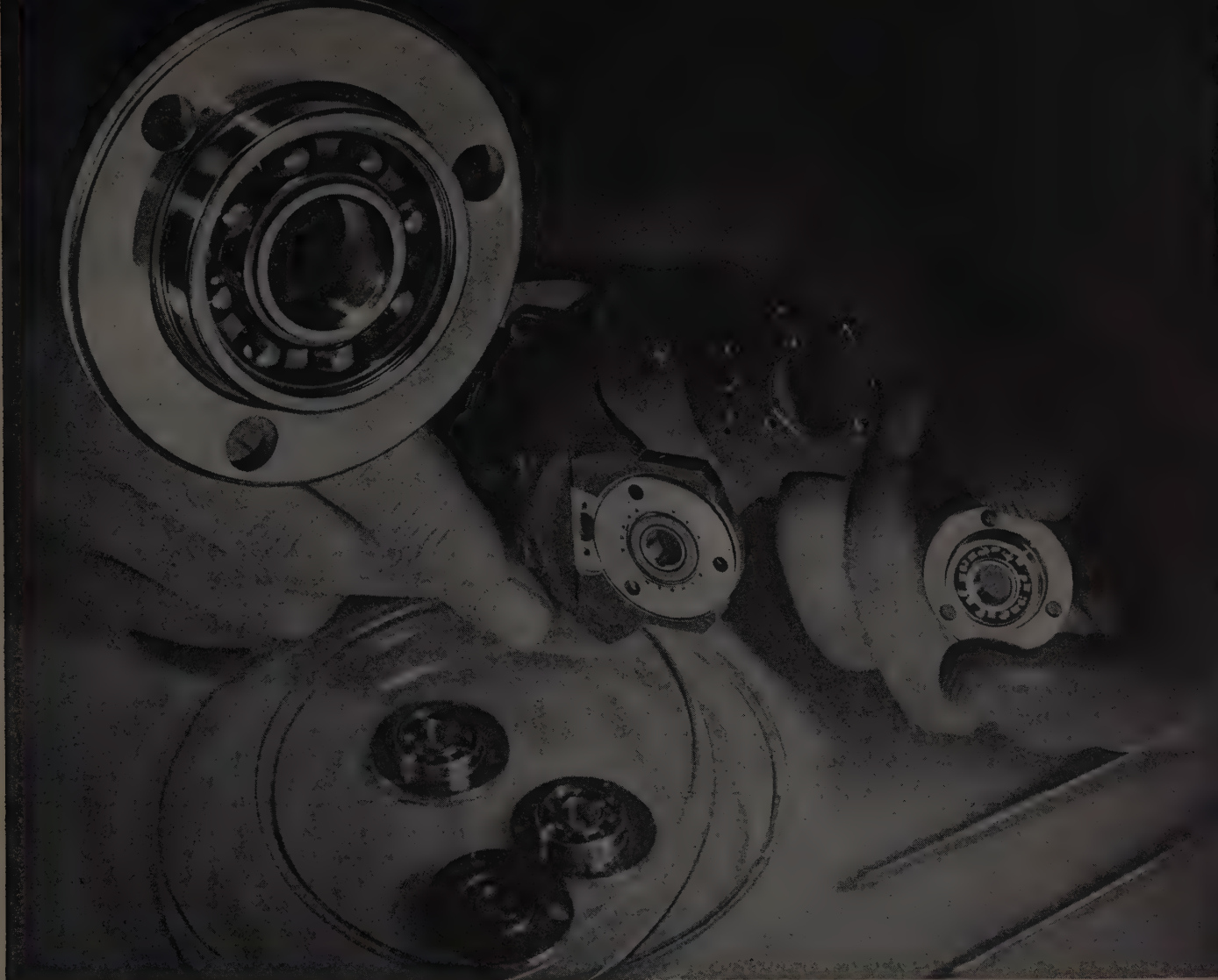
There are several ways of confining the plasma for the fusion process. Perhaps the best-known is the "pinch" effect—a confining magnetic field surrounds the plasma and acts as a magnetic wall. STL is working on ways of squeezing gas so rapidly that the molecules are literally swept up to speeds of 10<sup>6</sup> m/sec. The aim is to sweep the molecules in and hold them to "cook" in the center of the device while the fusion reaction is going on.

To do this, Dr. Clausen states, it's necessary to apply a magnetic field 10 times as rapidly as has ever been done so far. Nevertheless, he believes an airborne fusion powerplant will be developed some day.

Another way to contain plasma is to use a standing wave RF field such as can be produced in a cavity. The object is to drive both ions and electrons in a cavity toward an electric node by feeding the cavity with a waveguide. The RF waves beating back and forth on the walls of the plasma hold it in the center and the RF currents in the surface of the plasma heat it. The hot column of plasma thus obtained acts like a coaxial conductor at cutoff.—End

\*M. U. Clauser & E. S. Weibel, "Radiation Pressure Confinement, the Shock Pinch and Feasibility of Fusion Propulsion," STL Report.





Barden Precision Z96SW bearings specially designed for a gyro gimbal

## ***BARDEN*** Precision ball bearings set today's performance standards



The Torkintegrator, a high precision torque tester, was designed by Barden for extremely accurate response to torque variations. It is one of many Barden-developed test devices used for quality control or functional testing of Barden Precision ball bearings.

For accurate gyro indications, gimbals need bearings with uniformly low and predictable torque reactions. Other demands are extreme accuracy of rotation and exact positioning of the gimbal.

All standard *Barden Precision* bearings meet critical requirements for low torque and rotational accuracy. In addition, the special purpose Z96SW has these important design features:

**Barden-developed "W" retainer**—to minimize torque peaks . . . eliminate "windup"

**Precision flange**—for precise positioning and alignment . . . rigid mounting

**Shield on exposed side**—to prevent entrance of foreign matter

One of hundreds of Barden "specials," the Z96SW is an example of the results that stem from working creatively with Barden engineers from the earliest design stage.

Like all *Barden Precision* bearings, standard or special purpose, the Z96SW is planned for performance from research and design, through quality controlled production, functional testing and application engineering.

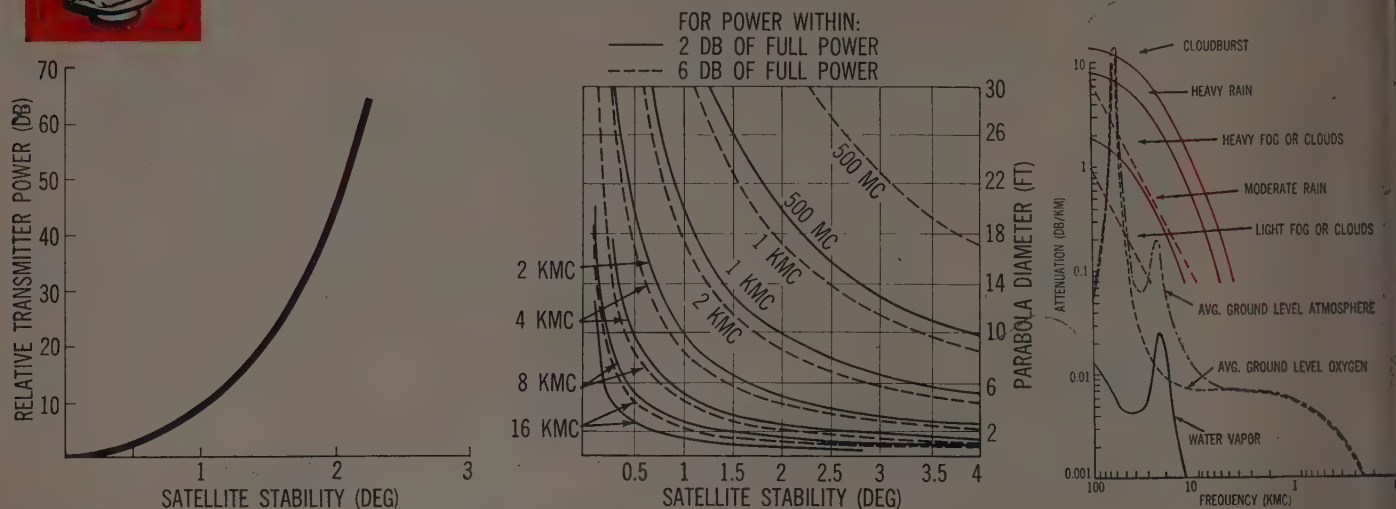
Your product needs *Barden Precision* if it has critical requirements for accuracy, low torque or low vibration . . . if it operates at extreme temperatures or high speed.

## **THE BARDEN CORPORATION**

75 E. Franklin St., Danbury, Connecticut • Western office: 3850 Wilshire Blvd., Los Angeles 5, California

SPECIFY **BARDEN PRECISION** BALL BEARINGS FOR: INSTRUMENTS • COMPUTERS AND RECORDERS • AIRCRAFT ACCESSORIES • MACHINE TOOL AND TEXTILE SPINDLES • OTHER PRECISION APPLICATIONS.





**FIGURE 1:** Satellite stability vs transmitter power and parabola size (left and center) and atmospheric attenuation by gases and precipitation. Attenuation curves are for water vapor of one g/m<sup>3</sup>, oxygen at 76 cm pressure at 20 deg C, and atmosphere of oxygen as above

and water vapor of 7.5 g/m<sup>3</sup> (average for summer day in temperate zone); moderate rain of four mm/hr, heavy rain of 25 mm/hr, cloudburst of 50 mm/hr, fog or clouds of 0.32 g/m<sup>3</sup> (about 400 ft visibility), and heavy fog or cloud of 2.3 g/m<sup>3</sup> (about 100 ft visibility).

## Reliability and stability most critical in satellite communications

What are the most important problems facing satellite communications designers and how can they be solved? The answer to this question is given in this condensed version of a chapter from a detailed study of satellite reconnaissance written by a group of 10 scientists and engineers at Du Mont Labs.\*

**O**F ALL the factors involved in the design of satellite communications systems, equipment reliability probably is the most critical. Exceptionally

high reliability is essential for the substantial operating life required for unmanned, non-recoverable communications satellites.

Probably next in importance is satellite stability. Because of the tremendous distances

spanned by high information rate satellite communications, high gain, narrow beam antennas should be used. But such antennas can be used only if a certain degree of satellite stability is insured.

Other factors that must be considered include: (1) S/N ratio vs bandwidth; (2) modulation characteristics; (3) frequency; (4) antenna directivity and gain; (5) power vs equipment size; (6) propagation in atmosphere, ionosphere, and space; (7) Doppler shift; (8) distances; (9) fixed vs movable antennas; (10) solar and cosmic noise;

(11) command link functions; (12) jamming; (13) data link considerations; (14) integration into overall vehicle.

For satellite-ground communication, the signal must pass through the atmosphere. This sounds worse than it really is—the distances involved usually are fairly short. If the signal follows a path normal to the earth, for instance, it has to go through merely 12 miles of atmosphere.

However, even if we assume that the signal will travel only through 50 miles or less of atmosphere, atmospheric absorption still does limit our choice

\*Space Reconnaissance Laboratory, Research & Development Div., Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N.J.



# VIGILANTE

*The Navy's new all-weather attack weapon system packs a precision punch... for limited war, or all-out conflict*

When North American's A3J Vigilante joins the fleet, the Navy will have its first supersonic carrier-based attack weapon system.

Vigilante is so versatile it can strike the restricted targets of limited warfare with extreme accuracy in any kind of weather—or deliver a knockout blow in all-out conflict. It can handle almost any kind of armament, including nuclear weapons, at extended strike ranges, high or low level. In performance, it's on a par with the fastest, highest-flying airplanes in the world today—yet it also operates with superior efficiency for low-altitude, long-range missions. Advanced boundary-layer control and full-span movable leading edge give the A3J good low-speed handling qualities for safe landings on car-

rier decks and short runways ashore.

The A3J is a true weapon system. All electronic systems and auto-flight controls are integrated, and were designed to enable the A3J to carry out all-weather, all-attitude weapon delivery. Its precision bombing-navigation system—outstanding in tactical efficiency—is the result of a coordinated effort by North American's Columbus and Autonetics Divisions.

Most important—the A3J has *men*: a pilot and a bombardier-navigator. For only men can respond to the unexpected. Only men can make decisions and report results. Only men can think. That is why, now and in the future, we must have manned weapon systems like the A3J Vigilante to keep our defense in balance.

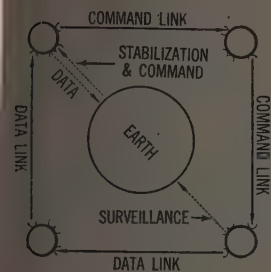


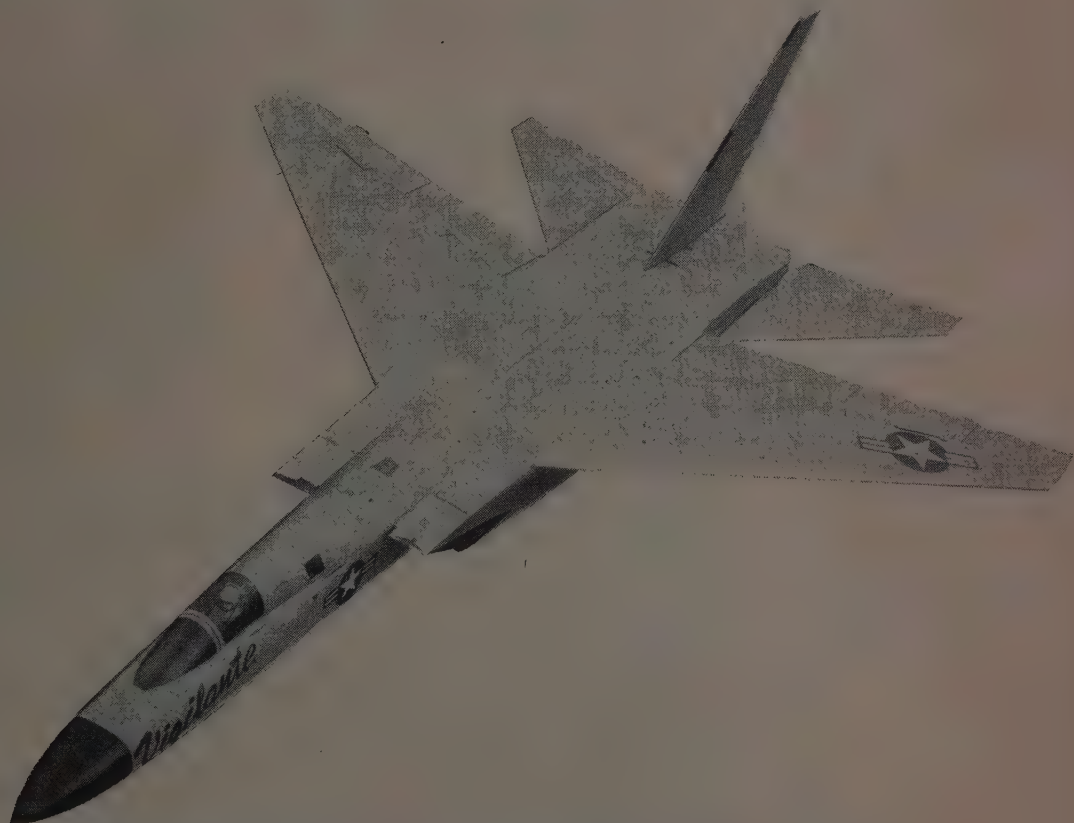
FIGURE 2: Four-satellite communication system.

f frequency. Uncondensed  
ases in the atmosphere limit  
ne frequency to about 20 kmc  
—they may attenuate this frequency by as much as 0.2  
b/km on an average summer  
ay in the temperate zone  
Fig. 1). Things get worse  
hen it rains even moderately:  
ow frequencies of 20 kmc are  
attenuated by about 0.4  
b/km. Taking precipitation  
into account and assuming that  
ropagation through heavy  
rain is impractical, we there-  
ore get a new upper limit of  
sable frequencies of around  
ve kmc.

Fading also must be considered. Standard practice calls for a fade margin of roughly 1/2 db/mile for 99.9 reliability. This indicates a margin of -25 db for satellite-ground communication to insure high propagation reliability.

The Doppler shift that must be expected is a function of the communications system's operating frequency and of satellite elevation angle and period—for instance, at an orbit period of 24 hours or more in the plane of the earth's equator, it becomes zero. How important Doppler effects are depends on the type of modulation and the system bandwidth.

Generally, satellites will  
more on next page



Also from Columbus—a new concept in Navy basic training

North American's new T2J is more than just a rugged, reliable, safe, easy-to-service jet trainer. It is an airplane specifically designed to meet the high standards set by the Navy for training carrier pilots. Top speed is 424 knots; stall speed is under 75. Engine can be removed in 7 minutes, replaced in 20. The T2J was designed, engineered, tested—and is now being produced—at the Columbus Division.



THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.

Columbus, Ohio





## Noise Figure vs Frequency

Frequency (mc)	Noise Figure (db)
300	6
1000	7-8
3000	7-8
10000	12
30000	16

have to be tracked. In special cases, however, it may be better to use suitably oriented fixed antennas with switching systems at RF or IF frequencies. For a multi-satellite system, it may prove worth while to combine these two methods. The tracking problem is not very serious—the tracking rate ranges from 18 to 60 deg/min, for instance, for a circular orbit at 300 miles above the earth.

The propagation characteristics of the ground-satellite link are quite similar to those of the satellite-ground channel. Of course, the transmitting equipment limitations now are much less stringent than on the satellite. The ground transmitter could have considerably greater power, so that a lower gain receiving antenna could be used on the satellite.

This naturally applies only to a single-satellite system. In a multi-satellite arrangement, command signals probably would have to be relayed through one or more of the satellites.

Stabilization commands are likely to be sent to each satellite of a multi-vehicle system as it passes over the main tracking station. As they are so critically important, it may prove best to have a separate link for them, with a simple antenna and receiver in each satellite. To provide for failure of this link, the general command link might have an alternate channel for stabilization information. (Generally, a reliability analysis may well show that extensive standby

# why **HYATT** is America's **NO. 1** **SOURCE** of jet engine roller bearings:

**HYATT** offers two decisive advantages:

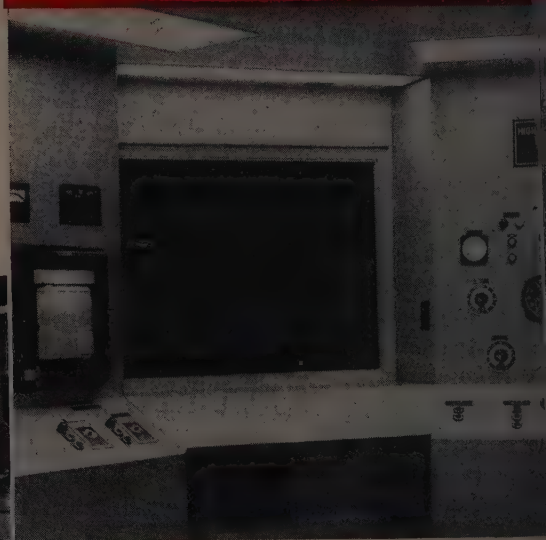
**1** Years of experience in cooperating with aircraft engineers to develop solutions to jet-age bearing problems.

**2** The skills and facilities to maintain *prototype quality* throughout on-time *quantity production*.

For size ranges and load ratings of standard **HYATT** Aircraft Bearings, request Catalog A-56. For expert engineering and production help in solving special bearing problems, contact Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.



**THE ME  
AN  
DEVELO  
DEPENDABI**

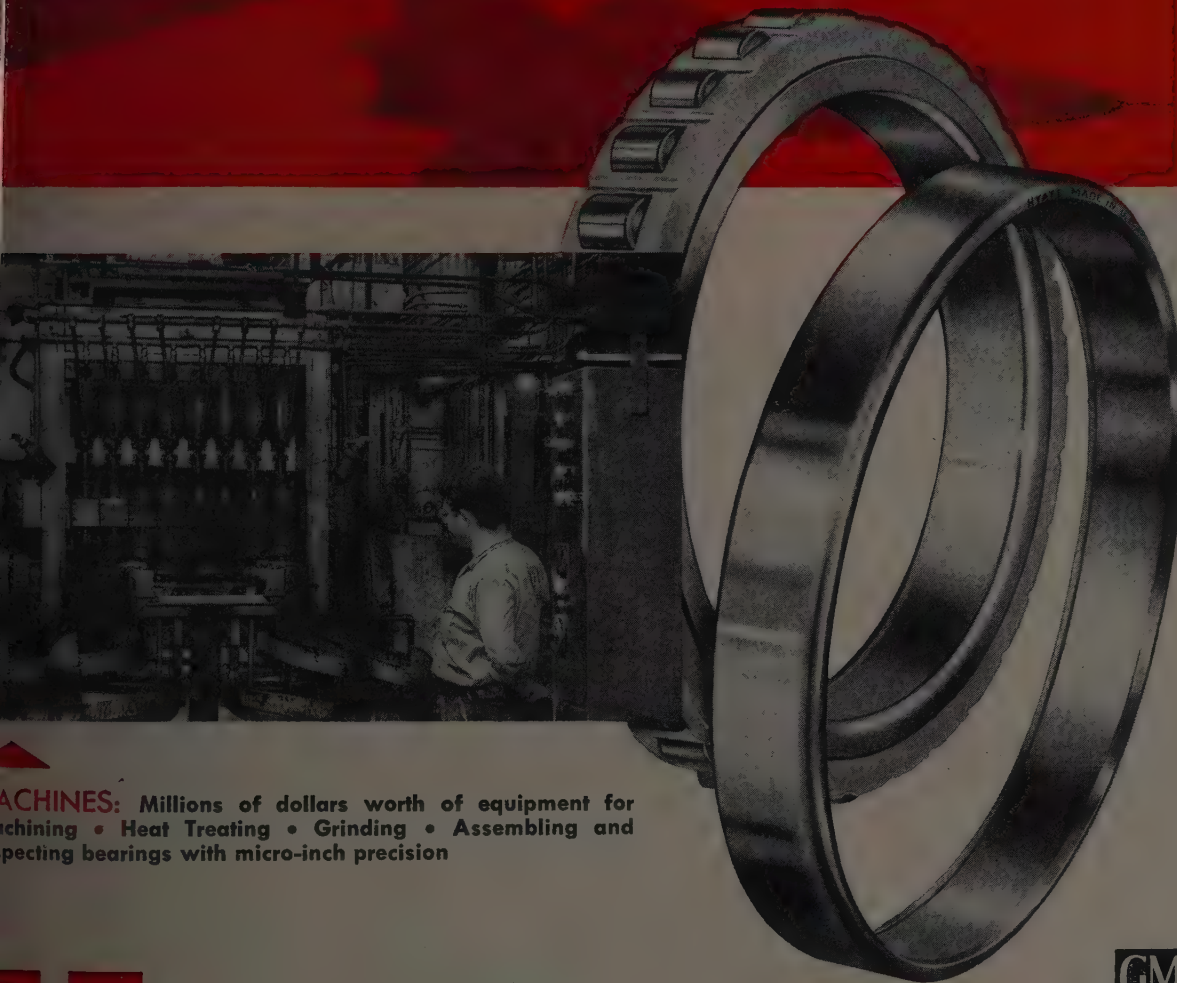


**FACILITIES:** This high speed test machine is part of a completely equipped metallurgical laboratory with modern equipment, for research and development in the fields of Higher Temperature • Higher Speeds • Heavier Loads in small areas, to meet aircraft requirements.

**MEN:** A highly-trained force of expert Metallurgists • Chemists • Designers • Engineers • Technicians • Production Craftsmen



# THE FACILITIES THE MACHINES TO AND DELIVER MORE AIRCRAFT BEARINGS!



**MACHINES:** Millions of dollars worth of equipment for machining • Heat Treating • Grinding • Assembling and inspecting bearings with micro-inch precision

THE RECOGNIZED **LEADER** IN CYLINDRICAL BEARINGS



# HYATT

**HY-ROLL BEARINGS  
FOR AIRCRAFT INDUSTRY**

Circle No. 16 on Reader Service Card in Product Review Section

provisions are needed for a multi-satellite system.)

Figure 2 shows a possible configuration for a four-satellite system. All inter-satellite functions could be handled by a complement of two antennas on each vehicle. Two legs of the inter-satellite link would be used for data transmission and two more for command signals.

If necessary, one additional antenna on each satellite would be enough for stabilization, command, and data transmission. However, as we have seen, in the interests of reliability a fourth antenna may prove desirable. This antenna—or at least a separate feed for the existing antenna—may be necessary for another reason, too: Very probably, stabilization and data recording will take place concurrently.

## Stability indirectly affects gain

The reason why satellite stability is so important is that it is directly related to antenna beamwidth and size, which in turn affect the overall system gain. For instance, Figure 1 shows that, for a 10-ft dish and a frequency of two-kmc and assuming minimum transmitter power is desirable, the satellite must be stable within one degree to keep the system gain within two decibels of the signal that would be available with perfectly aligned antennas. A stability of 1.75 deg would be needed to keep the gain within six decibels of full power.

At first glance, Figure 1 appears to show that the highest stability and frequency would be best. However, when all the aspects of the problem are considered—including propagation, mechanical, cost, and state-of-the-art factors—lower frequencies and stability will often prove desirable.

In cases for which the required satellite stability be-

more on next page



comes mechanically or economically impractical, an alternative solution is conceivable: A rather wide beam antenna could be used at the transmitting end of the system and a very high gain, narrow beam antenna at the receiving end. The latter would then home in on the transmitted signal by means of a sophisticated tracking mechanism.

This solution could be applied, for example, in a system using 18-ft dishes at two kmc for which a required satellite stability of 0.5 deg (needed to keep the link within two decibels of full power) could not be obtained. If the stability value had to be increased to 1.5 deg, an additional 21 db of transmitter power would be needed, and this probably would be undesirable.

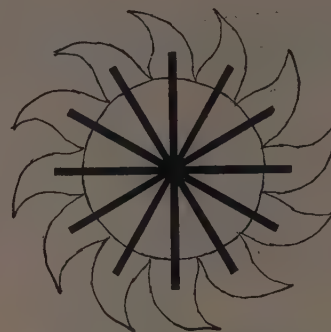
#### Power increase feasible for smaller antenna

On the other hand, an increase of six decibels in transmitter power in a system with a 6.5-ft transmitting antenna with one-decibel power points at  $\pm 1.5$  deg and a 25-ft tracked receiving antenna would provide the necessary gain at two kmc. (Other compromises might involve a frequency change as well.)

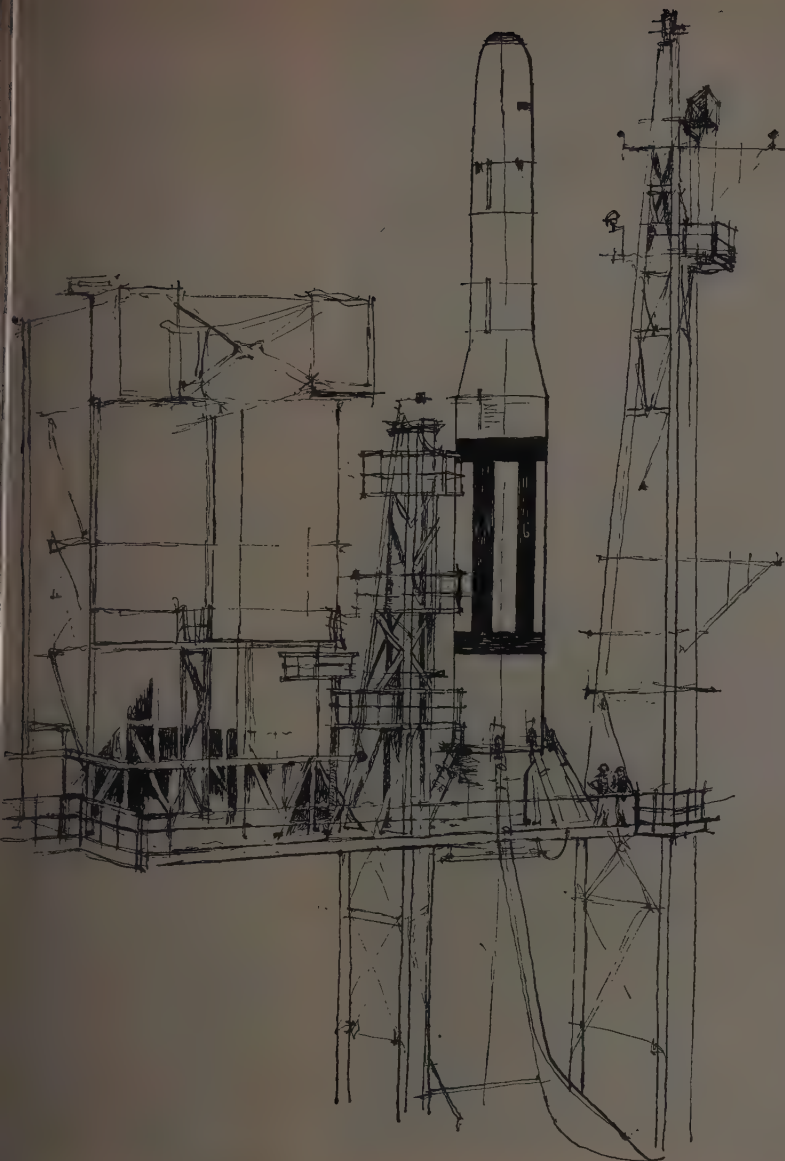
The problem of transmitter power vs satellite stability is further illustrated in Figure 1. Let's assume that, for a communication link between two satellites, we decide that propagation considerations require 18-ft reflectors to provide the necessary voltage at a two-kmc receiver. This, of course, calls for a certain transmitter power. Figure 1 then shows how much additional power is needed to overcome the satellite instability.

We can see that, if the satellites cannot be stabilized to  $\pm 2$  deg, we must consider lower frequencies or smaller dishes as well as higher trans-

There is nothing else like this under the sun. It is the Martin-Denver facility, birthplace of the Air Force TITAN. It is also this country's most advanced and fully integrated big-missile development center. Here, our most formidable weapon systems of tomorrow are being designed, built and tested from the smallest component to the total system—within a single 7,000 acre complex. Every top military and scientific expert who has seen Martin-Denver from *within*, considers it one of our most valuable national resources.







## SATELLITE COMMUNICATIONS

mitter power. However, it is quite impossible in this case to get enough transmitter power to overcome the system loss due to satellite instability. When power or dish size is limited, the highest usable frequency consistent with satellite stability would be used.

The minimum detectable signal, which will overcome the noise in the receiver output, depends largely on three factors: (1) receiver noise figure, (2) bandwidth, and (3) temperature. Any reduction in any of these factors reduces the amount of transmitted power needed for the system.

However, we must remember that the transmission rate is directly proportional to bandwidth. The narrower the bandwidth of a system, the lower is the information content.

The Table gives noise figures obtainable with present techniques. The low noise figures around three kmc usually are obtained with traveling wave tube amplifiers. These tubes are highly desirable in ground equipment; because of their size, they may not be suitable for satellite installation.

### In noise power formula, $T$ poses problem

For the designer of satellite equipment, an interesting problem lies in assigning the proper value for  $T$  in the equation for noise power ( $P_N$ ) in a given band:

$$P_N = KTB,$$

where  $K$  is Boltzmann's constant;  $T$ , temperature (in degrees K); and  $B$ , bandwidth. At least part of the resistance of the system supplying signal power to the receiver is due to antenna radiation. The proper temperature that goes with this resistance depends mainly on the direction in which the antenna is pointed. An antenna looking into interstellar space will have a lower effective temperature than one

more on next page

## HUNTER SPACE HEATERS

*for mobile  
and portable  
military shelters*



- designed and produced in accordance with military specifications for space, equipment and personnel heating requirements.

- 5 basic models — each custom-engineered for a wide variety of applications — for ground control and maintenance equipment in missile systems, radar, microwave and radio communication systems, etc.

- BTU/Hour range: from 15,000 to 60,000.

- multi-fuel-burning models; also models which burn any type gasoline.

- all models air-circulating, thermostatically controlled, all designed for cold starts as low as  $-65^{\circ}\text{F}$ .

*Other Hunter equipment for military applications: engine heaters; unpow-  
ered, instant lighting torches; refrigeration units.*

GET  
THESE  
BROCHURES  
TODAY!

*for complete  
specifications  
and details*

MH-162 "Hunter Space  
and Personnel Heaters"

MH-166 "Hunter  
Engine Heaters"

MH-167 "Hunter  
Instant Lighting  
Torches"



**HUNTER** MANUFACTURING CO.  
30529 AURORA RD.  
OLON, OHIO  
HEATING AND REFRIGERATION SYSTEMS  
Circle No. 17 on Reader-Service Card





# NOW... SUPER-STRENGTH PLATE IN ALCOA ALLOY 7079

## MEETS CLASS A SNT ULTRASONIC SPECIFICATIONS

Alcoa alloy 7079, used as a standard forging alloy for the last four years, is now available in high-strength plates for a wide variety of structural applications in the aircraft and missile industry. Already successfully used in the Convair 880 commercial jet airliner, the B-58 supersonic bomber and the Atlas Missile, production of this superior aluminum plate was made possible through Alcoa's new fabricating technique.

Available in thicknesses from 3 in. to 6 in., alloy 7079-T651 guarantees minimum mechanical properties in longitudinal, long and short transverse directions.

In plates 3 in. or thicker, alloy 7079 exhibits greater uniformity of mechanical properties, and in

addition possesses greater ductility than any other high-strength alloy. Alloy 7079-T651 plate is stretcher stress relieved 1½ to 3 per cent and may be machined to yield large parts with minimum distortion.

Identified by the approved Alcoa inspection stamp, alloy 7079 plate is ultrasonically inspected to Class A acceptance limits of the SNT Airframe Committee Report No. 1.

Call your Alcoa sales engineer for additional facts about alloy 7079-T651. He'll work with you in exploring and adapting its many advantages for better and lower cost products. Aluminum Company of America, 2027-A Alcoa Building, Pittsburgh 19, Pa.

### GUARANTEED MINIMUM MECHANICAL PROPERTIES—7079-T651 PLATE

Thickness Inches	Direction	Tensile Strength ksi	Yield Strength ksi	Elongation Per Cent in 2 in. or 4D
3.001-4.000	Longitudinal	70	60	6
	Long transverse	70	60	5
	Short transverse	64	55	2
4.001-4.500	Longitudinal	68	58	6
	Long transverse	68	58	5
	Short transverse	62	54	2
4.501-5.000	Longitudinal	68	58	5
	Long transverse	68	58	5
	Short transverse	61	53	2
5.001-5.500	Longitudinal	67	58	4
	Long transverse	67	58	4
	Short transverse	60	53	2
5.501-6.000	Longitudinal	67	58	4
	Long transverse	67	58	4
	Short transverse	59	52	2



Your Guide to the Best  
in Aluminum Value



ALCOA THEATRE  
Fine Entertainment  
Alternate Monday Evenings

### SATELLITE COMMUNICATION

pointed toward the earth.

The factors involved in the choice of a modulation system can best be shown by a comparison of AM and FM. Low power equipment, the modulation circuits needed for either AM or FM are roughly equal in size and weight. However, as the power level goes up, the modulators for AM systems become quite large while those for FM systems remain relatively constant.

### Power tubes are better suited to FM

The power tubes used in 10-30 kmc are electronical tunable types (klystrons, backward wave oscillators, etc.). These are quite well suited to FM but not to AM. The same holds true for voltage-tunable magnetrons at 1-10 kmc.

In wide band modulation systems, equipment operating at the higher frequencies again has a decided advantage. This is because electronically tunable tubes are modulated over wide bandwidths without any loss in power output.

One of the clear drawbacks of AM transmission is the susceptibility of AM signals to noise. From the relation:

$$[(S/N)_{FM}] / [(S/N)_{AM}] = 3F$$

it is obvious that, in exchange for bandwidth, the occupancy of FM gives much better transmission than AM.\* However, we should keep in mind that when the FM signal is weak compared with the noise, wide band FM is inferior to an equivalent AM system.

### Phase irregularities in wide band FM

Wide band FM systems also suffer from phase irregularities in the transmission path. With multi-path transmission, selective fading can cause phase variations even in the microwave region. Such variations can also occur when the side

\*H. S. Black, "Modulation Theory; Van Nostrand, 1953.



ands shift unequally because Doppler effects. In either case the distortions can be serious enough to make the signal unintelligible.

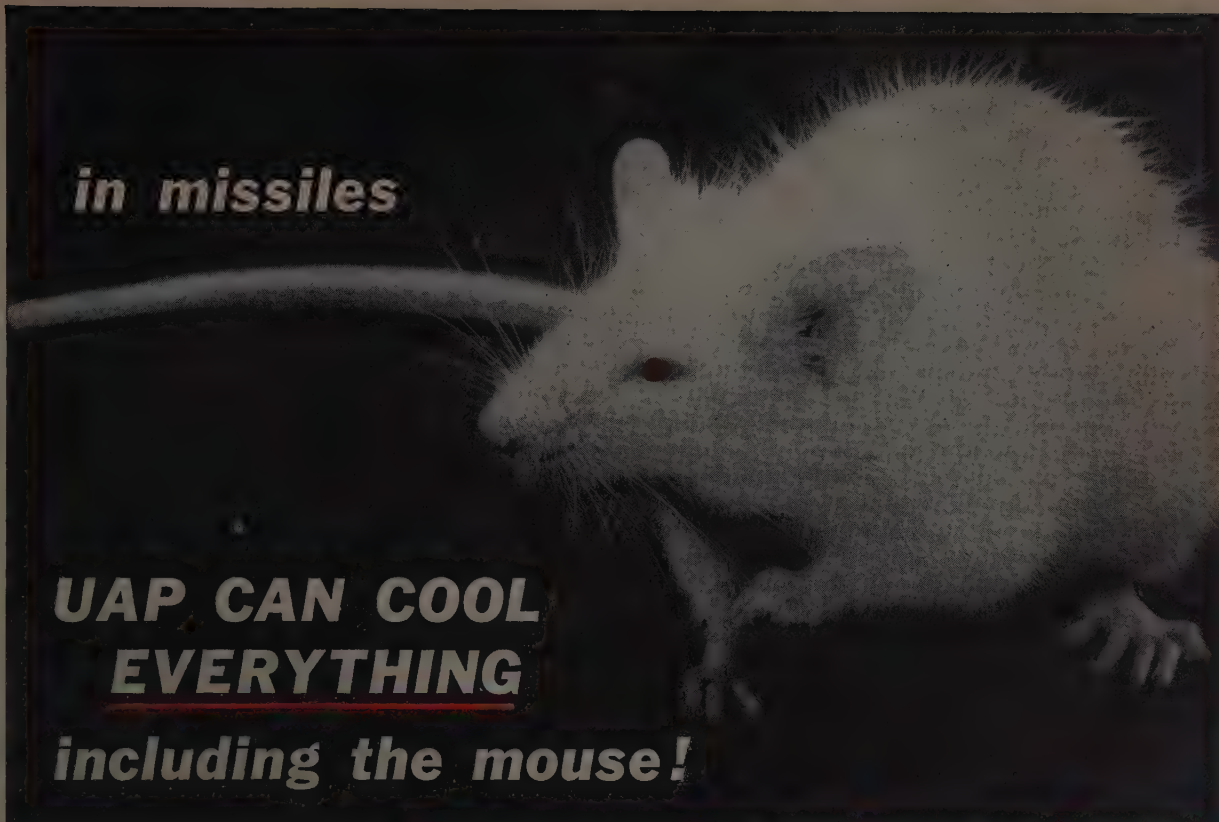
AM systems, on the other hand, suffer little from selective fading and Doppler. All in all the differences between AM and FM therefore are not as great as is often believed.

Pulse modulation also should be considered by the designer of satellite communications. Generally pulse modulation systems are more efficient in suppressing noise than either AM or FM systems. However, this advantage is gained only at the cost of more complex transmitting gear.

Generally it's true that, as frequency goes up, available transmitter power goes down. But by itself this does not accurately account for propagation performance—it must be related to such factors as antenna gain and fading. There are also certain major factors in equipment design that depend on frequency but not on propagation performance.

Probably the most important of these factors is efficiency of generation. Above 1000 mc, this drops off very quickly. At 100-1000 mc it is possible to get overall transmitter efficiencies of 20-30 per cent, but at 20 kmc efficiencies of five per cent are seldom exceeded at the present state of the art.

This does not mean that the lower frequencies necessarily are the better ones. If bandwidth, say, is a factor, then high frequency equipment certainly offers many advantages. With voltage-tunable magnetrons and backward wave oscillators, bandwidths of around 5-10 kmc can be obtained at frequencies of 30 kmc. However, if either the power or the frequency stability of the generated signal is a factor, then lower frequency equipment offers a better design basis, at least for the present.—End



**in missiles**

**UAP CAN COOL  
EVERYTHING**

**including the mouse!**

		Surface-Surface	Air-Surface	Air-Air	Surface-Air	ICBM	IRBM	IGBM	Drone	Tactical	Unknown	Army Ordnance	USAF	NAVY	Army Sig. Corps	Bur. Aeronautics	Unknown	Liq. Fuel Rocket	Solid Fuel Rocket	Booster	Ram Jet	Turbo Prop	Gas Turbine	Unknown	Radar	Inertial	Infra Red	Radio	Unknown
cooling systems	Mechanical Refrigeration																												
	Expendable Refrigeration																												
	Cryogenic																												
	Heat Transport																												
heat exchangers	Console Cooling																												
	Evaporative																												
	Liquid/Air																												
	Ammonia/Glycol																												
	Liquid/Gas																												
	Evaporative																												
	Liquid/Liquid																												
	Liquid Ammonia/Liq. Oxygen																												
valves	Hot Gas/Nitrogen Tetroxide																												
	Ammonia/Air																												
	Cold Plate																												
	Rupture																												
	Explosive																												
	Bleed																												
	Bypass																												
	Temperature Control																												
hand pumps	Pressure Control																												
	Solenoid																												
oil tanks	Thermostatic																												
	All-Attitude																												

The achievement chart proves UAP's extensive experience and ability in designing and building electronic cooling systems, components and flow control devices. Whether your electronic cooling problem involves airframe, guidance, propulsion or ground control equipment, UAP has the technical know-how to solve it! Call your UAP Contractual Engineering Office today!

CALIFORNIA, Burbank.....VI 9-4236 OHIO, Dayton.....BA 4-3841  
NEW YORK, New York.....MU 7-1283 CANADA, Montreal.....ME 1-4396

*a famous family of aircraft essentials since 1929*  
**UNITED AIRCRAFT PRODUCTS, INC.**  
1116 BOLANDER AVENUE, DAYTON, OHIO

Circle No. 19 on Reader Service Card in Product Review Section





New PRECISION  
FREQUENCY

## STATIC INVERTER SUPPLY

INPUT 28V D.C.  $\pm 10\%$

OUTPUT Nom. 115V  $\pm 2\%$

400 CPS  $\pm 0.01\%$

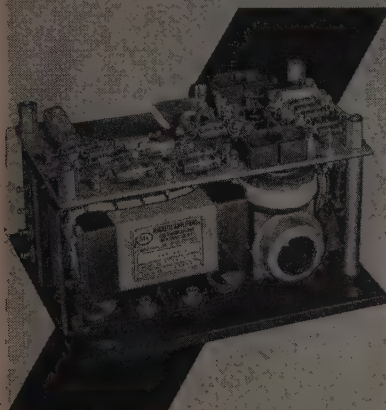
1  $\phi$  (2- or 3-phase output available)

RATINGS: 30VA 50VA 100VA

Higher ratings available.

### APPLICATION:

For gyro wheel supplies and where precise 400 cycle voltages are required in aircraft, radar and missile computers.



### FEATURES:

PRECISION OUTPUT FREQUENCY  
RUGGED

EXCELLENT WAVEFORM

SIMPLICITY OF CIRCUITRY

FAST STARTING TIME

GOOD VOLTAGE REGULATION

throughout an adjustable range

ISOLATED CASE DESIGN

HIGH RELIABILITY

VIBRATION ISOLATED

COMPACT

LIGHTWEIGHT

MILITARY SPECIFICATIONS

(Send for Bulletin S-864)



**MAGNETIC  
AMPLIFIERS, INC.**

632 TINTON AVENUE • NEW YORK 55, N.Y. • CYPRESS 2-6610

West Coast Division

136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665



Special Report

Space/Aero Electronics

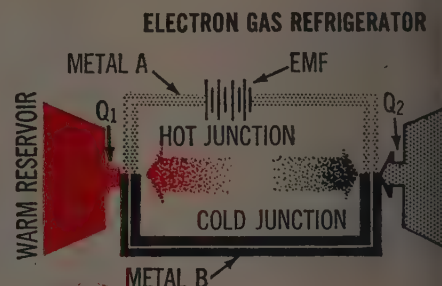
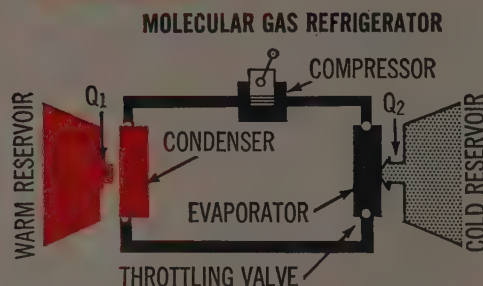


FIGURE 1: Comparison of refrigerators using molecular gas and electron gas. Q represents useful cooling

Wide use foreseen for

## applied thermoelectricity

R&D engineers at Nortronics are turning up ways to relate the venerable Seebeck and Peltier effects to modern designs in such areas as environmental conditioning, solar power conversion, ion propulsion, and above all electronics cooling.

by **M. B. Grier**, Project Engineer  
Nortronics Div., Northrop Aircraft, Inc.\*

**BY** MEANS of applied thermoelectricity, it is possible to convert heat to electricity and electricity to heat or cold directly without moving parts. The scientific principle that accounts for this has been known for quite a long time. The conversion of heat to electricity, the so-called Seebeck effect, was discovered in 1822. The inverse Peltier effect, the conversion of electricity to heat or cold, was uncovered in 1834.

Jean Peltier, a French physicist, observed that, if a voltage

is applied to a circuit consisting of two dissimilar metals, heat is absorbed at one junction of the circuit and emitted at the other. In 1911, Altenkirch and others applied this phenomenon to thermoelectric cooling. It soon became possible to draw an analogy between refrigerators using an electron gas (electrons have been considered a more or less ideal gas) and those using a molecular gas (Fig. 1).

In rocket vehicles, problems of aerodynamic heating and internal heat dissipation call for cooling systems of minimum weight and volume. In addition,

greater reliability needed. Peltier refrigerator may well prove to be the answer to these problems, since they have no moving parts and can probably be designed to odd-shaped spaces as supplemental coolers for hot spots and areas.

Peltier's phenomenon differs from Joule heating, which is produced by electric resistance in the circuit. Under the Peltier principle, the direction of the current flow determines whether heat is absorbed or emitted at a given junction. This can be shown in the following equation:

$$Q = IT_c(\alpha_1 - \alpha_2)$$

where  $Q$  is amount of heating or cooling;  $I$ , current flowing through the junction;  $T_c$ , temperature of the junction;  $\alpha_1$  and  $\alpha_2$ , the thermoelectric powers of the dissimilar materials comprising the junction. If we assume that half of the  $I^2R$  loss goes to the hot junction and the other half to the cold one, we can see

\*Nortronics Div., Northrop Aircraft, Inc., Hawthorne, Calif.



# FAR-REACHING EXTENSION FROM LIMITED ACTUATOR SPACE



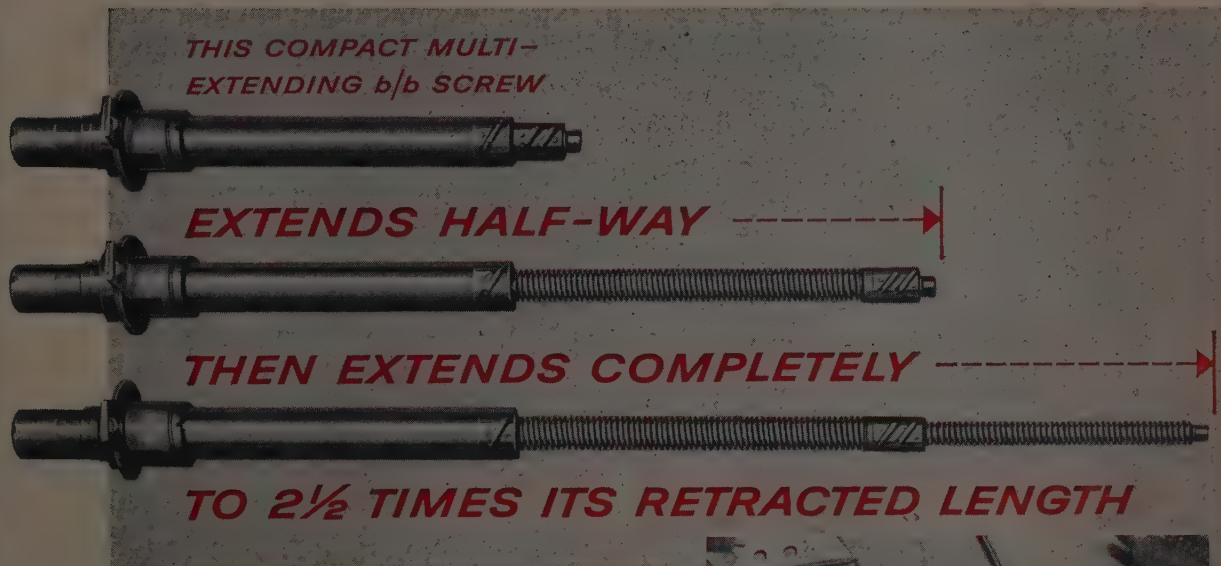
**FIGURE 2:** Two-stage Peltier refrigerator used to increase efficiency of infrared detectors (in this case PbS cell). Another version of this device (without envelope) is only  $\frac{1}{4} \times \frac{1}{4} \times 1\frac{1}{2}$  in., says Electronics.

to the lumped-parameter equation governing thermoelectric cooling:

$$= IT_c(\alpha_1 - \alpha_2) - \frac{(I^2/2)(\rho_1 L_1/A_1 + \rho_2 L_2/A_2) - (K_1 A_1/L_1 + K_2 A_2/L_2)(T_h - T_c)}{}$$
  
where subscripts 1 and 2 represent negative and positive legs of the couple, respectively;  $\rho$ , resistivity;  $A$ , cross-sectional area;  $L$ , length of a thermocouple element;  $K$ , thermal conductivity;  $T_h$ , temperature of hot junction (in degrees Celsius); and  $Q$ , useful cooling.

In this equation, we find that the useful cooling at the cold junction equals the Peltier cooling less half the  $I^2 R$  loss and the heat thermally conducted to it from the hot junction. We may then calculate the maximum possible temperature drop as well as the current required to produce it. Also, we can see that:

• cooling is proportional to  
**more on page 49**



Now Saginaw supplies the answer to your most difficult actuator space problems with the Multi-Extending Saginaw Screw! Utilizing Saginaw's time-proved recirculating ball principle in multiple telescoping sections, the Multi-Extending b/b Screw conquers actuator space obstacles designers have been seeking to overcome for years! Here's why:

- 1 UNIT EXTENDS** in a ratio of 2.5 to 1, providing maximum extension  $2\frac{1}{2}$  times the length of the retracted screw.
- 2 FAR GREATER LOAD CAPACITY** than any other telescoping device in its class.
- 3 FAR MORE PRACTICAL AND TROUBLE-FREE** than other telescoping units on the market.
- 4 PRECISE, DEPENDABLE POSITIONING** and control within thousandths of an inch.

• OVER 90% EFFICIENCY • REQUIRES UP TO  $4/5$  LESS TORQUE than acme screws • LESS DRAIN on power supply • CONSERVES SPACE AND WEIGHT • OPERATES DEPENDABLY at extreme temperatures • PERFECT FUNCTIONING with only initial lubrication



**USED ON THE COUNTRY'S MOST MODERN AIRCRAFT—Multi-Extending b/b Screw wing flap actuators being installed on the new Lockheed Electra.**

The Saginaw Multi-Extending Screw is also used to actuate speed brakes, afterburners, variable air inlets, canopies and similar critical components on today's newest aircraft.



Send today for the new 1959 engineering data book on Saginaw b/b Screws and Splines...or see our section in Sweet's Product Design File.

## Saginaw

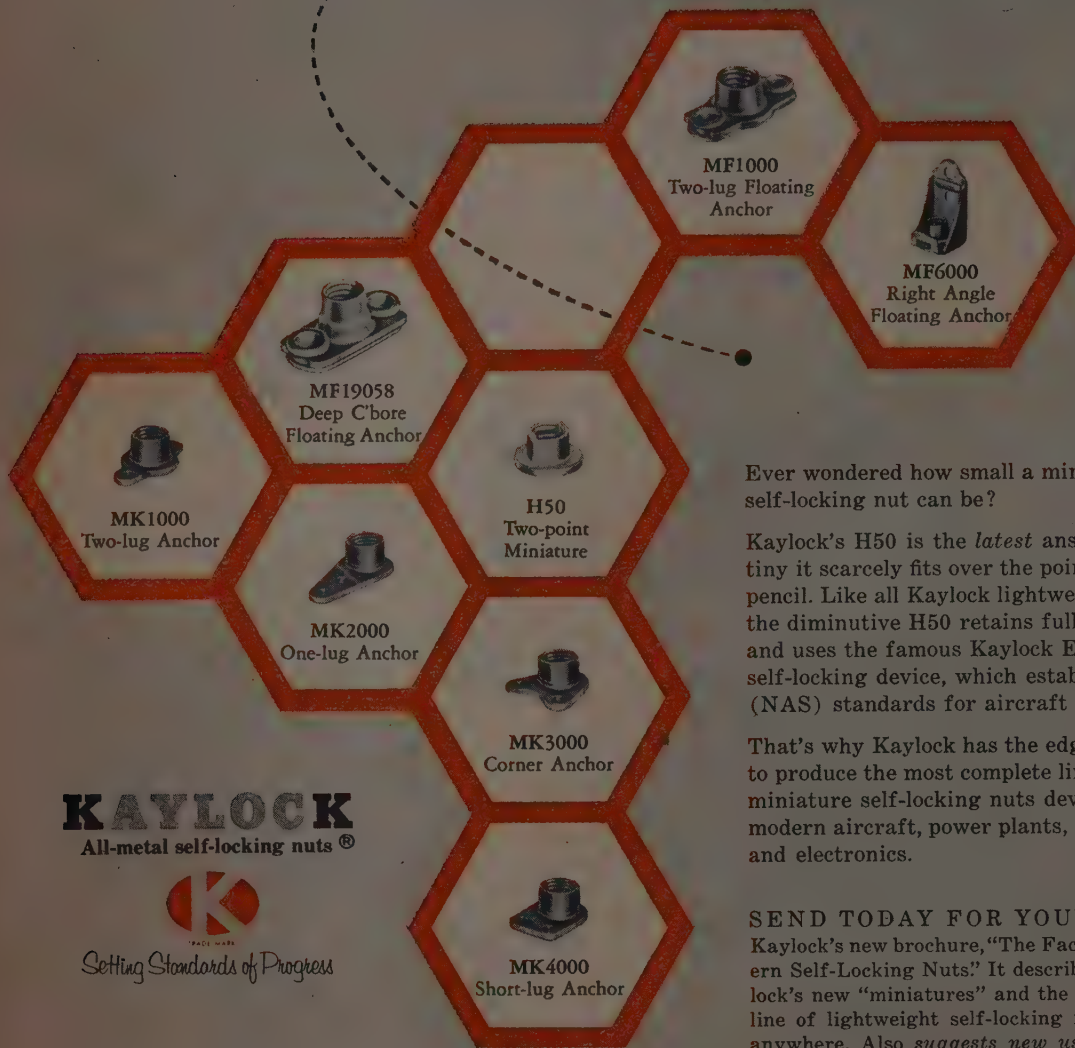
WORLD'S MOST EFFICIENT ACTUATION DEVICE

SAGINAW STEERING GEAR DIVISION, GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN

**ball bearing Screw**



HOW SMALL CAN A MINIATURE BE?



**KAYLOCK**  
All-metal self-locking nuts®



Setting Standards of Progress

Ever wondered how small a miniature self-locking nut can be?

Kaylock's H50 is the *latest* answer. It is so tiny it scarcely fits over the point of a lead pencil. Like all Kaylock lightweight nuts, the diminutive H50 retains full strength and uses the famous Kaylock Elliptical self-locking device, which established new (NAS) standards for aircraft lock-nuts.

That's why Kaylock has the edge and is able to produce the most complete line of miniature self-locking nuts developed for modern aircraft, power plants, missiles and electronics.

SEND TODAY FOR YOUR COPY of Kaylock's new brochure, "The Facts About Modern Self-Locking Nuts." It describes all of Kaylock's new "miniatures" and the most complete line of lightweight self-locking nuts available anywhere. Also suggests new use possibilities and applications! If you have a special lock-nut problem, a Kaylock sales engineer is as near as your phone. Call him today!

Circle No. 21 on  
Reader Service Card  
in Product Review  
Section



# SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

## NUMBER I—Decorative, Corrosion-Resistant Finishing with Iridite

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a decorative finish or a good paint base for non-ferrous metals. However, continued developments are so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can combine salable appearance with durability in one finish at a competitive price advantage. Report II on paint base, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, as a basis for this discussion, a "decorative" finish is considered as any chromate film that is used as a final finish in itself. It may be truly decorative in that its sole purpose is to enhance the beauty of the product. For example, a bright chrome-like finish or a pleasing bronze appearance are among the many effects that can be obtained. It may be functionally decorative in that it reduces reflectivity for camouflage purposes or provides a means of color-coding parts. But, in all cases, the Iridite films protect the metal against corrosive attack.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. These films can produce a wide variety of pleasing appearances. The basic colors of the Iridite coatings are grouped below by metals.

**ZINC and CADMIUM:** Metallic bright, light iridescent, iridescent yellow, bronze, olive drab.

**COPPER, BRASS, BRONZE:** Metallic bright, yellow.

**ALUMINUM ALLOYS:** Clear, iridescent yellow, brown.

**MAGNESIUM ALLOYS:** Light brown, dark brown, black.

**SILVER:** Metallic bright.

In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

Depending upon the metal and the Iridite used, corrosion resistance of clear and bright films ranges from mild passivity to as high as 500 hours in salt-spray; on heavier dark films, salt-spray resistance ranges from approximately 100 to 1000 hours.

It is this combination of decorative and corrosion resistant properties that accounts for the widening use of Iridite finishes. For example, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, a combination of lustrous chemical polishing of the as-cast surface of zinc die castings and good resistance to corrosion. Further, in many cases,

### WHAT IS IRIDITE?<sup>®</sup>

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

sizeable savings in the cost of buffing and electroplating are realized.

On many steel parts, a simple system of zinc or cadmium plate and bright Iridite is used instead of more costly electroplated finishes to provide a bright, decorative and protective finish with tremendous savings in material, equipment and labor.

In finishing aluminum, where corrosion resistance or paint adherence is the prime consideration, the aircraft industry has all but abandoned the anodizing process in favor of recently developed chromate conversion coatings, among them Iridite #14 and #14-2 (Al-Coat). These formulations and their method of application can be varied to retain the original metallic appearance while providing acceptable corrosion resistance, or to produce a fully colored brown finish that offers exceptional corrosion protection. Again, time and manpower savings are astounding—one company saved at least \$15,000 a year on maintenance of racks alone and another \$40,000 on materials and labor in only nine months. In addition, of course, hundreds of thousands of dollars are saved by eliminating the need for expenditures for generators, heating equipment and racks.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to having decorative and protective functions, these chromate coatings form an excellent base for organic finishes and bonding compounds. They have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 E. Monument Street, Baltimore 5, Maryland.

### THE THERMOELECTRICITY . . .

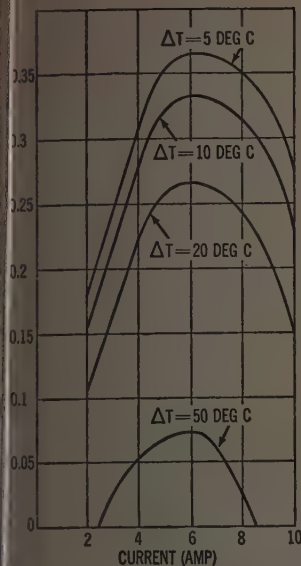


FIGURE 3: Useful cooling vs current for various temperature drops in a typical single-stage micro-refrigerator. Ingot is 0.89 in long and 0.09 cm<sup>2</sup> in area.

the difference in thermoelectric power of the materials forming the junction, so that materials with high thermoelectric powers are needed for efficient cooling;

- high electric conductivity is required to minimize Joule heating; and low thermal conductivity is required to reduce the flow of heat from the hot to the cold junction.

### Temperature drop lessens as load goes up

Most metals have low electric resistivity and also low thermoelectric power. In contrast, certain semiconductors, such as germanium and silicon, have high thermoelectric power; but their low electric conductivity is a drawback. Furthermore, their crystal lattice structure contributes to high thermal conductivity.

The answer would seem to lie with intermetallic-compound semiconductors. In recent years, these have been

more on next page

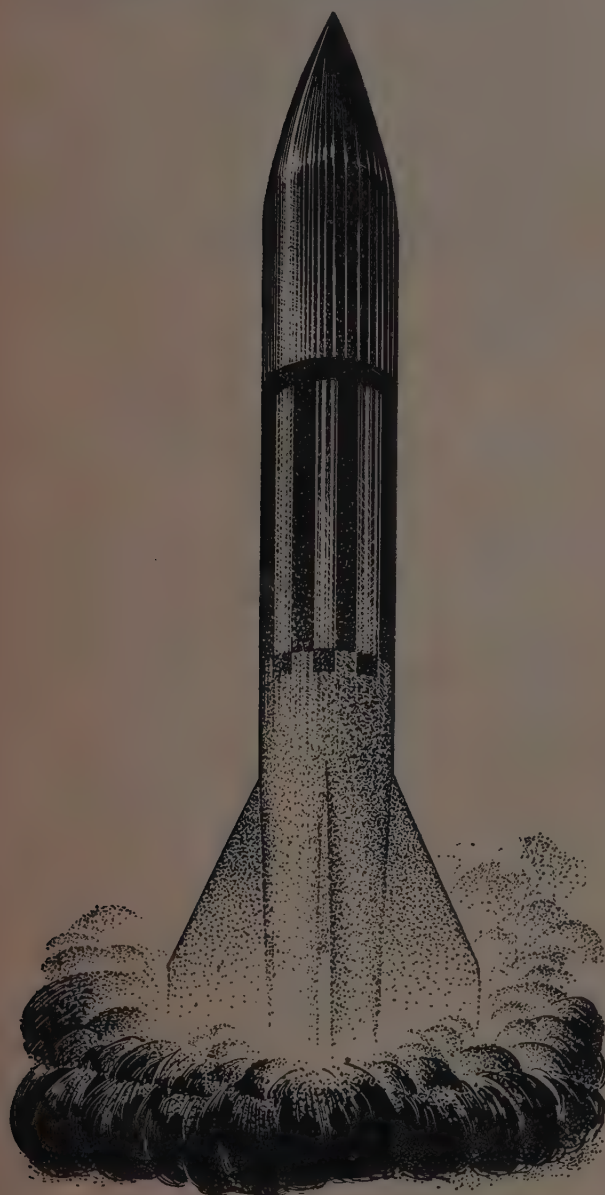


# Special Armco Stainless Steels...

## For Components that Must Withstand

### Heat and

### High Stresses



For missile frames, propulsion units, guidance systems and accessories, special Armco Stainless Steels offer combinations of properties that yield major design and production advantages. In addition to good corrosion resistance, they have high strength-weight ratios over a wide temperature range, cost-reducing producibility, plus many special characteristics. And all of them are commercially available.

**Armco PH 15-7 Mo**—Newest of Armco's precipitation-hardening stainless steels. Offers exceptionally high strength-weight ratios to 1000 F, and is available in all forms including foil. Offers unique design and production advantages in frames, solid propellant casings and tanks.

**Armco 17-7 PH and 17-4 PH**—Grades widely used in missiles and aircraft. Provide high strength to 900 F and excellent fabricating characteristics. 17-7 PH produced in all forms, 17-4 PH in bar, wire and billets.

**Armco 17-10 P**—Non-magnetic precipitation-hardening grade with high mechanical properties. Available in bar, wire and forging billets, 17-10 P is useful for instrument, guidance and accessory parts requiring this unique combination of characteristics.

**Armco 22-4-9**—An austenitic Armco Stainless with high strength and hardness up to 1600 F. High temperature hardness, resists wear, erosion and galling. Available in bar and billets.

Consider the design and production advantages offered by these special Armco Stainless Steels. They may help you improve performance or cut the cost of units you make. For complete information on their properties and fabrication, mail the coupon or describe your requirements in a letter to the Armco Sales Office nearest you.

ARMCO STEEL CORPORATION, 2618 Curtis St., Middletown, Ohio

Send me information on these special Armco Stainless Steels:

New  
steels are  
born at  
Armco

Armco PH 15-7 Mo  
Armco 17-7 PH  
Armco 17-4 PH

Armco 17-10 P  
Armco 22-4-9

NAME

COMPANY

STREET

CITY

ZONE

STATE

## ARMCO STEEL



Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

## THERMOELECTRICITY . . .

produced with high thermoelectric emf and moderately low electrical resistivity. Good examples are Bi<sub>2</sub>Te<sub>3</sub> and alloys of ZnSb and BiSb.

For a given set of material parameters, the achievable temperature drop decreases with increasing load. In the case shown in Figure 3, cooling is 73 mw for a 50-deg C drop at about six amperes, while for a 10-deg C drop at the same current it is 330 mw.

To study Peltier cooling capabilities, Nortronics built a single-stage electronic refrigerator (Fig. 4). We found that the amount of cooling varies with the temperature range as well as with the degree of thermal isolation. Insulated with cotton and cooled with a (15 deg C) water, the refrigerator cooled a small tray of water sufficiently to produce a block of ice within a few minutes.

Adequate cooling is particularly important for passive radiation detectors (such as photosensors), whose sensitivity is far greater at very low temperatures (about -195 deg C) than at ambient. Experiments in this area have yielded at least two miniature mechanical cryostats — refrigerators based on the Joule-Thomson effect. These are said to achieve temperatures as low as -195 deg C.

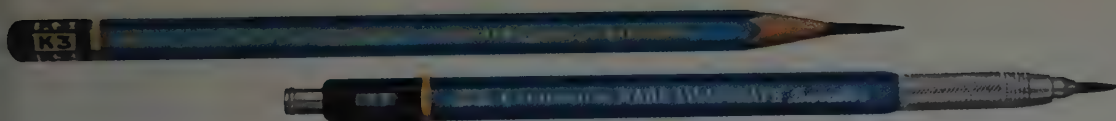
## Moisture and impurities cause trouble

However, these relatively expensive miniature devices are troublesome when it comes to purging moisture and impurities from the system. What is really needed to solve these cooling problems for passive radiation detectors is a compact refrigerator that is intrinsically related to the detector itself and can operate independently of external refrigerant sources.

In experiments with a two-stage Peltier refrigerator, we have achieved a total temperature

more on page





# and now *Duralar*<sup>\*</sup> joins this famous family of fine pencils

pencil specifically designed for work on matte-facing film of Mylar®, DURALAR is the newest in the line of fine MARS drafting products. All are from West Germany and made to meet the high-precision standards. Below ● Bright-hued LUMOPENCILS in 24 colors for color-coded drafting and reproduction ● LUMOGRAPH graphite drawing pencils in 19 degrees; some degrees available with eras-

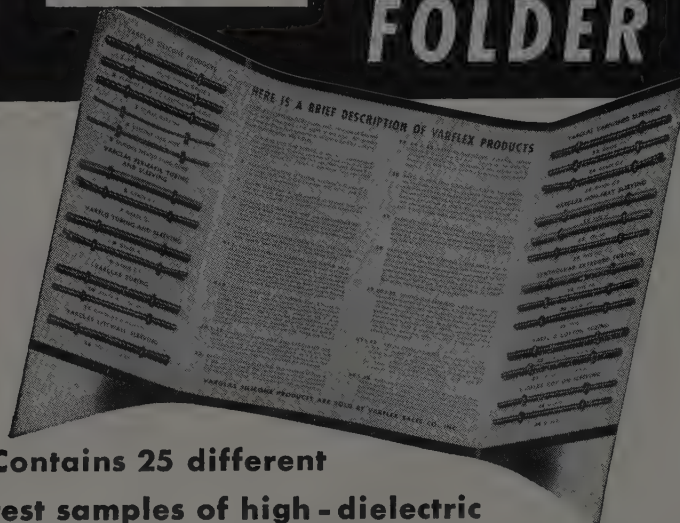
ers, some with special chisel points ● TECHNICO lead holders for color and black graphite drawing, with new sure-hold finger grips and degree markings for quick identification; also with clips, for pocket use ● NON-PRINT pencil and leads make notes and sketches that will not reproduce ● Pencil sharpeners in STANDARD and "DRAFTSMAN" models; latter with adjustable point-length feature. © T.M. FOR DUPONT'S POLYESTER FILM

**MARS**  
J. S. STAEDTLER, INC.  
HACKENSACK, NEW JERSEY





# Send for this **FREE SAMPLE FOLDER**



## Contains 25 different test samples of high-dielectric **INSULATING TUBING and SLEEVING**

*Includes samples and descriptions of...*

**VARGLAS SILICONE**—Class H tubing, sleeving, lead wire, tying cord. Withstands temperature from  $-85^{\circ}\text{F}$  to  $500^{\circ}\text{F}$ .

**PERMAFIL-IMPREGNATED VARGLAS TUBING**—Fiberglas impregnated with General Electric Permafil.

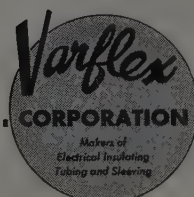
**VARGLAS SLEEVING AND TUBING**—synthetic-treated, varnished, lacquered, saturated and others.

**VARGLAS NON-FRAY SLEEVING**—three types available. Withstands temperatures up to  $1200^{\circ}\text{F}$ .

**VARFLO TUBING AND SLEEVING**—full range of colors, sizes and grades. Vinyl coated Fiberglas.

**VARFLEX COTTON TUBING AND SLEEVING**—varnish or lacquer impregnated—all NEMA grades.

**SYNTHOLVAR EXTRUDED TUBING**—listed by UL for use at  $105^{\circ}\text{C}$ . Various formulations to meet unusual requirements.



**MAIL COUPON TODAY  
FOR SAMPLE FOLDER**

**VARFLEX CORPORATION**  
500 W. Court St., Rome, N. Y.

Please send me free folder containing samples of your electrical tubing and sleeving.

I am particularly interested in insulation for .....

Name .....

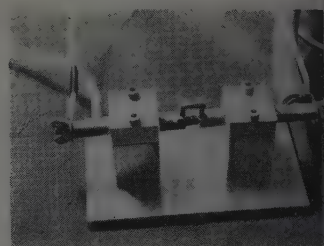
Company .....

Street .....

City ..... Zone ..... State .....

Circle No. 25 on Reader Service Card in Product Review Section

## THERMOELECTRICITY



**FIGURE 4:** Single-stage Peltier refrigerator devised at Nortronics. The legs of the couple are about three mm square.

ture drop of about  $50^{\circ}\text{C}$  starting from a hot junction temperature of  $20^{\circ}\text{C}$ . This is enough cooling power to increase the useful sensitivity of such common photoconductive detectors as the lead sulfide (PbS) cell.

Figure 2 shows our photo-sensor - refrigerator mounted within an evacuated aluminized envelope. The refrigerator-cell assembly fits on thermally massive copper support posts inserted in an insulating support disk. The supports have cooling fins and lugs to receive leads. The photoconductor (in this case a PbS cell) is fastened to the cold junction. The photoconductor leads are brought up and fed through the base.

Driving emf for the device is about 250 mv, producing a current of about 10 amp (2.5 w). Ample power for intermittent operation is supplied by a zinc-silver oxide secondary cell that furnishes about one volt with very high current level for long operating periods. For continuous operation, you'll have to add a silicon rectifier.

## Direct conversion of nuclear energy

As we have noted, the thermoelectric refrigerator characteristically produces a sharp temperature drop as the temperature of the hot junction of the cascade increases. Typically, a prototype unit that gave  $50^{\circ}\text{C}$  cooling with the hot junction at  $20^{\circ}\text{C}$  yielded only  $30^{\circ}\text{C}$  cooling



# Some Advantages of Peltier Refrigeration

- You don't need a compressed nitrogen supply
- No moisture or impurities to clog pressure lines
- You don't need high pressure tanks
- Electric power requirements are small
- Few Peltier stages are needed for intermediate cooling
- Cooling reduces cell heating at high Mach number

With the hot junction at -20 deg C.

Among the more promising applications for thermoelectric power generation is the direct conversion of nuclear energy to electricity without intermediate moving parts. As the energy source we might choose a heat-producing isotope (such as plutonium 210) that emits easily shielded radiation in the form of beta or alpha particles. With the thermoelectric material shielded from harmful radiation, the heat energy could be allowed to pass.

An alternate method would be to use a radioactive source combined with a thermoelectric material that retains useful thermoelectric characteristics when transmuted. Obviously, we could use the more conventional reactor heat transfer configurations to minimize the transmutation of the material by radioactivity. This would, of course, involve a pressurized gas or fluid heat exchanger medium.

Work at Nortronics has shown a thermoelectric solar converter can be built that is comparable in efficiency—8-14 per cent—with the silicon solar cell under free space conditions. Using concentrators with this device, you could get even greater efficiency. Such a device may be expected in the near future.

For ion propulsion, thermoelectric devices may be coupled with nuclear reactors to

more on next page



## SILVERCEL® BATTERY POWERED RAT STALKS SUBS - WITH DEADLY ACCURACY!

Through every stage of its submarine-stalking mission, the Navy's revolutionary RAT (rocket-assisted torpedo) depends on YARDNEY SILVERCEL® BATTERIES to power remarkable propulsion and homing devices.

From the largest and most complex missile to the smallest subminiature device, today's advanced technology requires maximum energy from a package of minimum size and weight. As in the RAT, YARDNEY

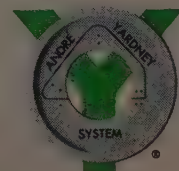
SILVERCEL® BATTERIES provide reliable energy with only 1/5 the size and 1/6 the weight of ordinary batteries. They are used in 19 U. S. missiles... including major intercontinental and intermediate-range missiles.

Write today for complete technical data and literature to find out how you can gain needed power, save vital space and weight.

## YARDNEY ELECTRIC CORP.

"Pioneers in Compact Power"\*

40-50 LEONARD STREET, NEW YORK 13, NEW YORK



Patents granted and pending.  
Copyright 1958  
Yardney Electric Corp.  
\*Trade Mark

MANUFACTURERS OF YARDNEY SILVERCEL®, YARDNEY SILCAD® AND YARDNEY ARCTIC® BATTERIES  
Circle No. 26 on Reader Service Card in Product Review Section



THOR TITAN ATLAS BOMARC POLARIS TALOS

# D-C POWER

**CHRISTIE**

**THERE IS A REASON...why CHRISTIE**  
was selected as the principal source of  
D-C Power Supplies for all the above  
projects...**RELIABILITY**

CHRISTIE'S rigid Quality Control is approved by the A.E.C.  
and leading Aircraft and Missile Manufacturers.

## CHRISTIE ELECTRIC CORP.

3410 W. 67th St., Los Angeles 43, Calif., Dept. AA

Precisely regulated Power Supplies of permanent stability. Ratings up to 1500  
amperes. Bulletin on Standard Militarized units available on request.



Circle No. 27 on Reader Service Card in Product Review Section

## THERMOELECTRICITY

produce an electric accelerating field. Also, solar energy converters will be a source of standby and auxiliary power for the larger space vehicles and may become the main power source for smaller ones.

The applications of thermoelectricity in maintaining environmental conditions inside spacecraft are fairly obvious. Atmospheric decontamination

and heating and cooling sure bets. Since one of the advantages of thermoelectric devices is that they have no moving parts, their use would greatly lessen one of the critical problems foreseen in space flight—the prevention of variable extraneous movements. It would leave only movements of the crew to be dealt with.—End

## 'Mayer's Grand Guide'

### AMERICA'S BEST COMMERCIAL AND INDUSTRIAL REFERENCE DIRECTORY



a MONUMENTAL work, magnificently bound, absolutely UP TO DATE and completely different, is the SEARCHLIGHT for all Export and Import Merchants, Commission Agents, Manufacturers' Representatives, Buying Agents and Makers or Producers of the 21 AMERICAN, 17 EUROPEAN and 73 countries of ASIA, AFRICA, includes cities in AUSTRALIA, INDIA, FED. OF MALAYA, NEW ZEALAND, likewise the SOUTHWEST PACIFIC, and other countries in the MIDDLE, NEAR and FAR EAST ASIA & AFRICA.

These 111 Countries where M. G. G. has had wide circulation for fourteen years, constitutes the BEST and SELECT market of the world.  
CIRCULATION: 30,000 copies.

This will be a wonderful opportunity for you to present your products to the most outstanding and selective IMPORTERS of the Universe, and assures to you a prompt and widespread promotion if you advertise in «MAYER'S GRAND GUIDE». Our No. 9 issue for the year 1959 is in process of advanced preparation and printing will soon commence.

This highly recommended Guide is printed on first class paper, and is written in two languages: English and Spanish.

We still have a few copies available of the 1958 (No. 8) edition.  
**PRICE ONLY . . . U. S. \$10.00**

**Mr. JOSEPH MAYER, Publisher,**

Cassilla Correo No. 1561

**BUENOS AIRES (ARGENTINA)**

We have a few locations open for REPRESENTATIVES

Circle No. 28 on Reader Service Card in Product Review Section  
SPACE/AERONAUTICS



THERE  
IS  
NO  
BETTER  
WAY  
THAN  
WITH  
**LIQUID  
OXYGEN**

Liquid oxygen is the safest, most efficient oxidizer commercially available for missile and rocket propulsion systems. It is stable, non-toxic, non-corrosive, and easy to dispose of when necessary. That's why it is used in IRBM and ICBM motors.

Large volumes of liquid oxygen can be stored indefinitely in LINDE designed and built storage units — right where it is needed. Vaporization losses are minor — can be held to *less than 5 per cent per year*.

Using LINDE's methods, liquid oxygen can be transferred safely from storage — without pumps — ten times faster than previously.

LINDE can supply large quantities of liquid oxygen almost anywhere in the nation — quickly, and at a cost of only pennies per pound.

If you are concerned with the nation's vital missile and rocket development program, take advantage of LINDE's more than 50 years of experience in producing, transporting, and storing liquid oxygen. Call the LINDE office nearest you, or write: LINDE COMPANY, Division of Union Carbide Corporation, Dept. J-1, 30 East 42nd Street, New York 17, N. Y.

Circle No. 29 on  
Reader Service Card  
in Product Review  
Section

*Linde*  
TRADE-MARK



"Linde" and "Union Carbide" are  
registered trade-marks of Union Carbide Corporation.





**ACCO**  
for Better  
Values

## NEW "NO-MAG"

### NON-MAGNETIC AIRCRAFT CABLES

- GOOD THERMAL CHARACTERISTICS
- CORROSION RESISTANT
- HIGH FATIGUE RESISTANCE
- HIGH ABRASION RESISTANCE
- PREFORMED CONSTRUCTION



TRU-LOC  
SWAGED FITTINGS

## Eliminates Instrument Interference!

• Just as we expected, many aircraft designers were interested in the recent announcement of our new non-magnetic aircraft cable. If you did not see it, "NO-MAG" has these characteristics:

**NON-MAGNETIC PROPERTIES...** "NO-MAG" cable is made from type 305 stainless steel. It remains non-magnetic after severe cold working—in contrast to standard stainless steel aircraft cable which shows a pronounced increase in magnetism after swaging, wire drawing or similar operations.

This non-magnetic property of "NO-MAG" cable eliminates instrument interference from cable magnetism.

**CORROSION RESISTANCE...** New "NO-MAG" cables have corrosion-resistant qualities similar to, but slightly better than, cables made of standard stainless steel.

**GOOD THERMAL CHARACTERISTICS...** The thermal expansion characteristics of new "NO-MAG" cable are much closer than those of standard stainless steel or carbon steel cables

to the characteristics of aluminum alloys used in aircraft. This greatly simplifies maintaining cable tension under various changes in temperature.

**HIGH FATIGUE RESISTANCE...** Preformed construction and careful processing give new "NO-MAG" cable high fatigue resistance.

**HIGH ABRASION RESISTANCE...** New "NO-MAG" cable shows greater abrasion resistance than standard stainless steel aircraft cables.

**TENSILE STRENGTH,** while lower than that of stainless and carbon steel, is sufficient to enable replacing these, size for size, with "NO-MAG" on many applications where the characteristics of "NO-MAG" are required.

**USE WITH SWAGED TERMINALS...** Swaged terminals can be applied to standard AN dimensions.

**COMPLETE RANGE OF SIZES, CONSTRUCTIONS...** New "NO-MAG" is furnished in sizes from 1/16" to 1" in all of the standard aircraft cable constructions.

*Get the complete story on this new technical development for the aircraft industry. Write today to Detroit office.*

**Automotive and Aircraft Division  
AMERICAN CHAIN & CABLE**



601 Stephenson Bldg., Detroit 2

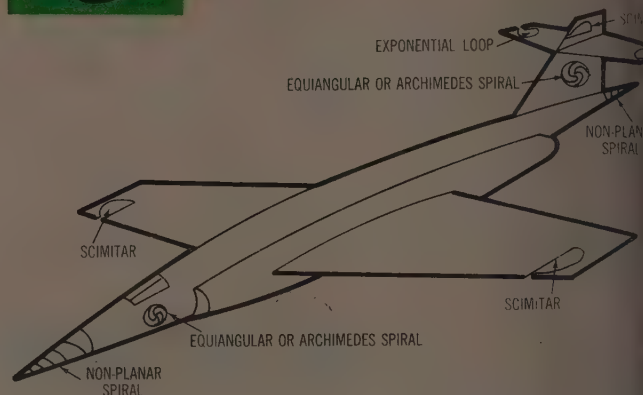
6800 East Acco Street, Los Angeles 22 • Bridgeport 2, Conn.

Circle No. 30 on Reader Service Card in Product Review Section



## Special Report

Space/Aero Electronics



TYPICAL installation of spiral, scimitar, and exponential loop antennas.

## Spiral antennas meet needs of new vehicles

The first real breakthrough in antenna design for high performance aircraft and missiles came in 1956 with the application of the equiangular concept to the Archimedes spiral. Many advanced designs have since followed. The more important of them are reviewed in this article.

by Edwin M. Turner

Aerial Reconnaissance Laboratory,  
Wright Air Development Center\*

IN 1954, a bandwidth of one octave, or a frequency ratio of 2, was considered excellent. A frequency ratio of 3 was just about the ultimate. Today, we can produce efficient antennas with frequency ratios of 20 or more.

\*Aerial Reconnaissance Laboratory, Wright Air Development Center, USAF Air Research & Development Command, Wright-Patterson AFB, Ohio.

Notable among the new antennas are the "scimitar," the "valentine" (derived from the equiangular spiral antenna), and the many forms of logarithmic periodic structures. Recently, both spiral types and periodic structures have been made non-planar. This gives them a unidirectional pattern with constant impedance over very large bandwidths with or without cavity backing.

The logarithmic periodic structures are especially interesting, because they afford such great flexibility in controlling polarization. Their efficiencies are also well up over 95 per cent (provided good conducting materials and low loss dielectrics are used).

Until recently, the practice has been to build antennas with fixed patterns and polarizations. Since it is possible to null any fixed-polarization antenna, this type is no longer



## PRINCIPAL CURRENT ANTENNA TECHNIQUES

9 MC

ed wire, trailing wire, tail & g caps, airframe, pods, horizontal & vertical stabilizer

59 MC

ips, tuned stubs, fixed wire, rite loops, pods, scimitars (aircraft structure), valentines (aircraft structure), spirals, logarithmic periodic structures, conical spirals

499 MC

ubs, biconical, partial sleeve, o-loaded stub, helix (above 0 mc), plastic rods, pods, irals, scimitars (aircraft structures), valentines (aircraft structures), logarithmic periodic structures, conical spirals

0 MC—19 KMC

ubs, helix, flat biconical, slot-d waveguides, top-loaded stub, rns, traveling wave slot, cones, irabolos, Luneberg lens, printed arrays, spirals, scimitars, valentine, logarithmic periodic structures, conical spirals

39 KMC

ens, slotted helix, horns, slotted aveguides, printed arrays, spirals, scimitars, logarithmic periodic structures, conical spirals

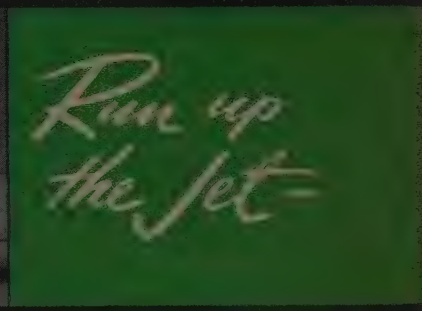
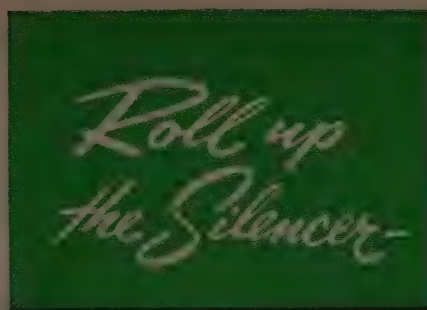
Y KMC & Up

rinted arrays, lens, optical techniques

adequate for many countermeasure purposes. Designers now want to be able to shift the pattern and polarization most at will. Developments along these lines show considerable promise.

Basically, there are two types of spiral antennas in use: (1) the Archimedes spiral, for which  $R$  equals  $ae$  and (2) the equiangular spiral, for which  $R$  equals  $e^{a\theta}$ , where  $a$  is the radius vector from the origin to a point on the curve;  $\theta$  is the angle or rotation (in radians);  $a$ , a constant denoting the conductor's rate of expansion, and  $e$  the constant 2.718.

more on next page



*For moderate, economical silencing of jet-powered commercial and military aircraft...*

## NEW KOPPERS PORTABLE RUN-UP SILENCER TAKES THE PUNCH OUT OF JET NOISE

Now, airports, air bases and manufacturers of jet engines or airframes can run up jet engines without complaint or creating physical hazards. The Koppers Portable Run-Up Silencer reduces noise by 25 to 30 decibels—lessens the risk of hearing damage to operating personnel, improves community relations and reduces speech interference.

The new portable silencer inhibits the generation of jet engine noise, rather than suppressing

it after the noise has reached full intensity. The unit is light in weight and completely portable—no direct attachment to the aircraft or engine is necessary. Look to Koppers with its longest experience in the industry to solve your aviation noise control problems.

Write for Koppers new sound control brochure today. KOPPERS COMPANY, INC., Sound Control Department, 9201 Scott Street, Baltimore 3, Maryland.

Official  
United States  
Navy Photographs

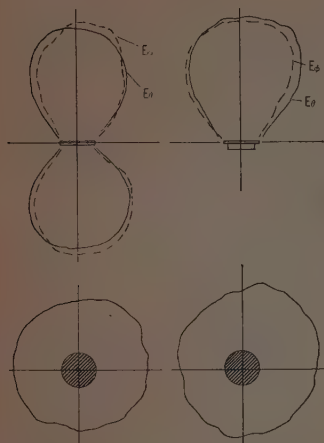


## SOUND CONTROL

Engineered Products Sold with Service

Circle No. 31 on Reader Service Card in Product Review Section





**FEEDING** the two arms of a coplanar spiral antenna 180 deg out of phase produces a circularly polarized conical beam (left) about 80 deg wide in both planes. If the arms are fed in phase, a stub-type pattern is produced (right) with a null on the axis.

These antennas can be built as either single or double spirals, and can be fed either balanced or unbalanced with co-ax or waveguide. With the unbalanced feed the beam will tilt an average of about 10 deg from its axis.

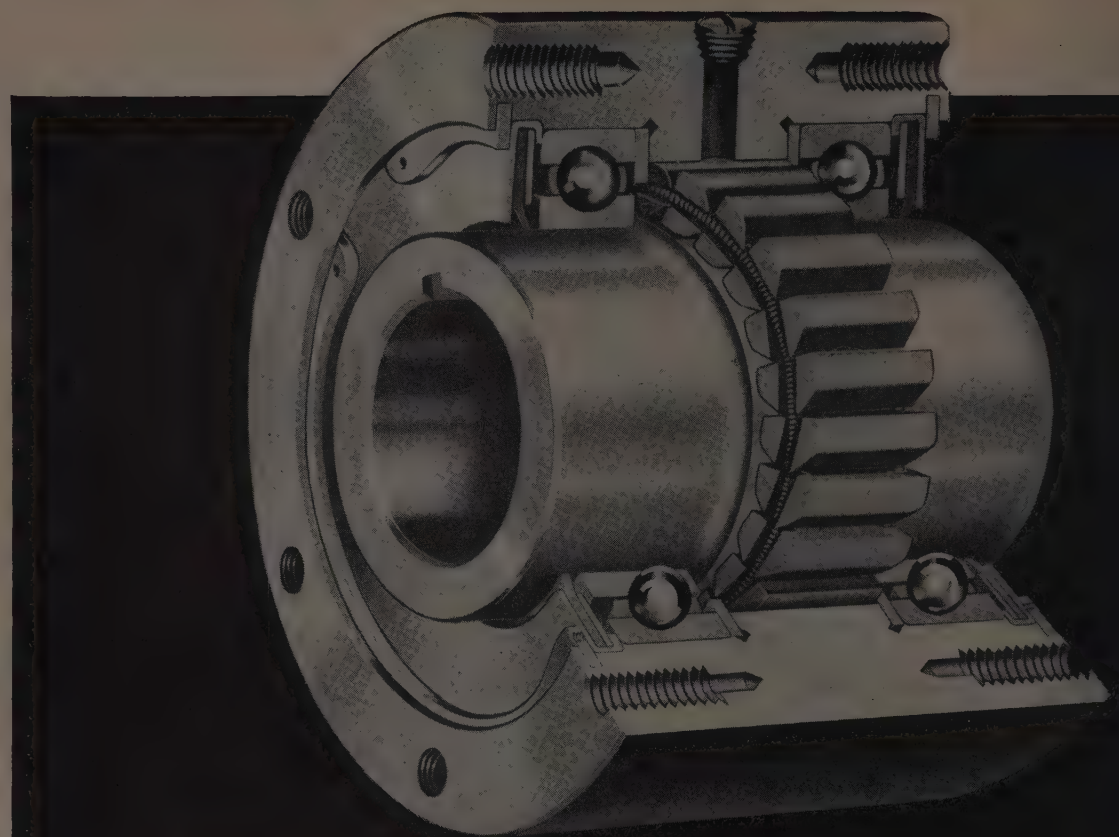
Spiral antennas are unique in having a self-adjusting aperture that accounts for their constant beamwidth. The electric phenomenon responsible for this beam compensation is different for the two types of spirals; however, the far-field effect are similar.

Upper frequency limits for both antennas are determined by the construction accuracy of the feed points. The lower limit is set by the circumference of the outer turns of the antenna.

If circular polarization is wanted, this lower limit has to be about one wavelength at the lowest frequency. Considerably smaller sizes can be used if circular polarization is not needed.

Coplanar antennas are particularly well suited to printed circuit techniques and can be

# The OVER-RUNNING CLUTCH With



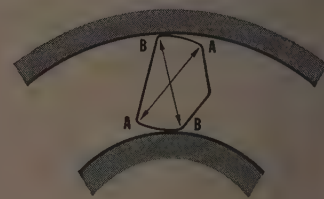
## OVER-RUNNING INDEXING BACKSTOPPING

### VERSATILE FORMSPRAG DESIGN MEETS VARIETY OF NEEDS



Formsprag Clutches simplify design problems in missiles, jet and conventional aircraft, and helicopters on over-running, back-stopping and indexing applications. The new aircraft design bulletin "Building More Performance in Less Space" illustrates their use in auto pilots, rudder actuators, canopy actuators, compressors, seat ejectors, gas turbine starters, landing gear actuators, ammunition feeders, etc. Write today for your copy.

### HERE'S



The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension A is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.



# Greatest Torque Per Inch - Per Ounce

How do you pack more performance into less space? More specifically, what clutch gives you more torque, in less space, than ever before available . . . for today's rigid requirements on aircraft and missile applications?

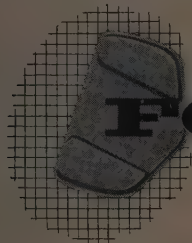
Answer . . . the Formsprag clutch, in a variety of designs and sizes, positively gives you higher torque capacity for its size and weight than any other clutch! In addition, this advanced mechanism features internal simplicity (just four basic parts), no measurable backlash, light weight, compactness, extreme precision and long, trouble-free life. The exclusive, patented Formsprag principle is unlimited in application, yet this full-complement sprag type clutch is extremely simple in design and operation.

Formsprag offers a size and model clutch for every over-running, indexing

or back-stopping application. Standard models are available in sleeve bearing, ball bearing, miniature and large bore backstop types. All are illustrated in the new Formsprag catalog, complete with specifications, performance data and design ideas. Formsprag engineers also offer a complete design service on special clutches, including prototype production facilities. Write for the complete Formsprag catalog, or send details of your application for a consultation with the Formsprag Engineering Department.

**FORMSPRAG COMPANY**  
23597 Hoover Road, Dept. 100  
Warren (Detroit), Michigan

In Canada: Renold Chains Canada, Limited  
In United Kingdom: Renold Chains, Limited  
*Distributors in Principal Cities*



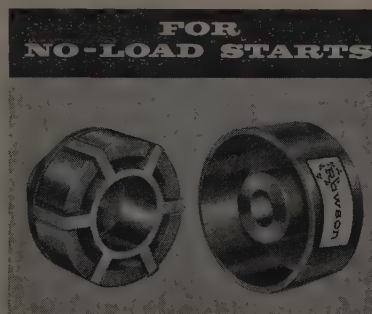
## FORMSPRAG CLUTCHES

World's Largest Exclusive Manufacturer of Over-running Clutches



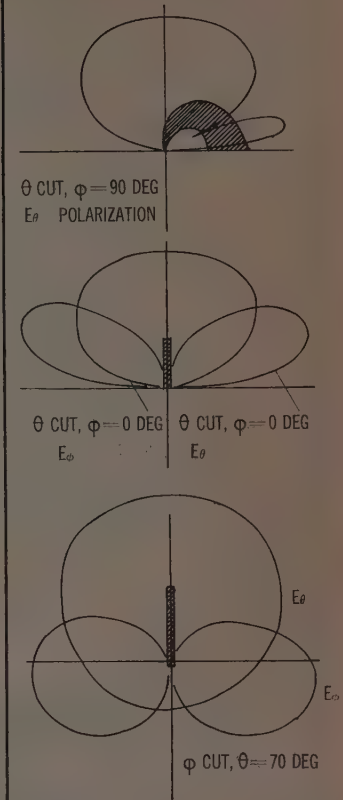
An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.



Specify Rawson Automatic Centrifugal Clutches and Clutch Couplings. They protect the prime mover, eliminate need for costly reduced voltage starting equipment, permit use of less expensive smaller motors to start high inertia loads. Completely automatic and entirely mechanical in operation. Rawson clutches provide full overload protection, never need adjustment. Write for the new Rawson Clutch Catalog now.

### SPIRAL ANTENNAS . . .



TYPICAL patterns of co-planar spiral antennas.

made cheaply. They inherently lend themselves to flush mounting.

Used with a cavity, spiral antennas become unidirectional, with a gain of three decibels over that of free-space units. However, the cavity reflections do restrict the pattern bandwidth. With conventional cavities, bandwidths of about 3:1 are practical.

The inherent impedance of the spiral antenna is relatively constant. It can be adjusted to almost any nominal value between 25 and 200 ohms by varying such parameters as the thickness of the conductors, the taper rate of the conductors, the spacing of the cavity backing, etc.

Non-planar spirals have patterns and impedance characteristics similar to those of the

*more on next page*

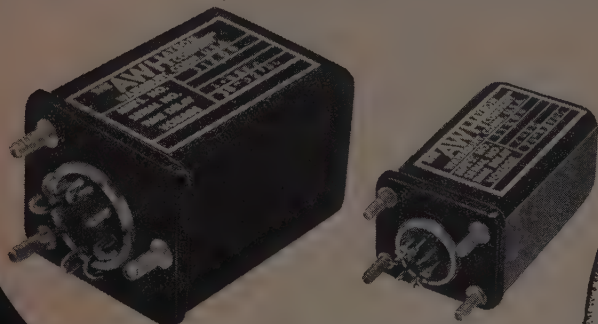


RUGGED

RELIABLE

New!

TRANSISTORIZED

MINIATURE ELECTRONIC  
TIME DELAY RELAYS  
31200 SERIESSUB-MINIATURE ELECTRONIC  
TIME DELAY RELAYS  
31300 SERIES

## A. W. HAYDON COMPANY'S TRANSISTORIZED SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS!

SAVE SPACE AND WEIGHT!

	Miniature Series	Sub-Miniature Series
Cross Section	1 1/16" x 1 1/32"	3 1/32" x 1 1/16"
Length	2 1/4" long	2" long
Weight	6 ounces	3 ounces
WRITE FOR:	Bulletin AWH TD-503	Bulletin AWH TD-504

## TEST-PROVED PERFORMANCE!

High Temperature: 125°C (250°F).

Vibration: 2000 CPS at 15 g.

Contact arrangements up to 4 pole double throw.

Unique transistorized R.C. time constant network.

Time Delays from 50 MS to 120 seconds. Longer Delays available.

Hermetically sealed housings.

MEET REQUIREMENTS OF MIL-E-5272A.

The  
**A.W. HAYDON Company**

223 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

Design and Manufacture of Electro-Mechanical Timing Devices



Circle No. 33 on Reader Service Card in Product Review Section

coplanar types, except that the patterns are always unidirectional. When the spiral is projected onto a cone with a taper of 20 deg or less, the front to back ratio exceeds 25 db.

A non-planar spiral is stable over at least a 20:1 frequency ratio, with very good circularity. It can be built either with a conventional co-ax line or with an exponentially tapered flat conductor. (With the conductor, it can be made about 25 per cent smaller, but is somewhat harder to build especially in small quantities.) The antenna feed must be balanced, however, to prevent beam tilt.

The non-planar conical spiral is relatively insensitive to a cavity environment provided that the apex of the cone is pointed in the direction of radiation.

The scimitar is a derivative



LOGARITHMIC periodic tures have essentially constant impedance and highly efficient patterns over band-widths great as 20:1.

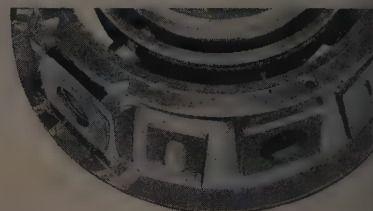
of the spiral antenna. basically a folded monopole whose conductor expands exponentially.

This antenna presents a small narrow cross-sectional area to the air stream. It has great mechanical strength in large at the stress point and is not isolated from ground plane.

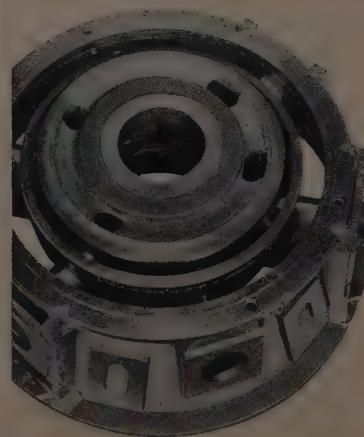
The curve for the outer dimensions of the antenna given by:

$$R = ke^{a\theta}$$

56 details of stainless steel jet engine component brazed in three steps with no distortion or oxidation by Wall Colmonoy . . .



## Specialists in Furnace Brazing for High-Temperature Service



This jet engine diffuser casing is typical of the aircraft and missile parts being furnace brazed at Wall Colmonoy. As originators of Micro braz Process brazing, we have an unmatched background in the nickel alloy brazing of stainless steel and superalloys. Our facilities also include vacuum furnaces for degassing and brazing titanium bearing alloys. Our three plants are ready and able to engineer and process your components. Call or write today.

**STAINLESS PROCESSING DIVISION**  
WALL COLMONOY CORPORATION  
19345 John R Street • Detroit 3, Michigan

PENNSYLVANIA: Bristol Pike, Morrisville, Pa., CALIFORNIA: 1565 Bluff Road, Manteca, Ca.

Circle No. 34 on Reader Service Card in Product Review Section  
SPACE/AERONAUTICS



here  $k$  is the scaling factor and  $a$  a constant denoting the rate of expansion of the outside and inside curves of the scimitar. The inside curve is defined by the same equation, except that the value of  $a$  is smaller. The origin of the curve is displaced from the feed point.

The efficiency of the scimitar antennas is well above 5 per cent over their entire useful band. Bandwidth is usually limited to a 4:1 frequency ratio, because of pattern shifts. However, if the pattern requirements are not critical, it is easy to get a frequency ratio of 10:1.

The lower cutoff frequency is usually determined by the length of the inside conductor. It must be one quarter wavelength or greater. The upper end of the band is limited by the co-ax or waveguide feed line cutoff.

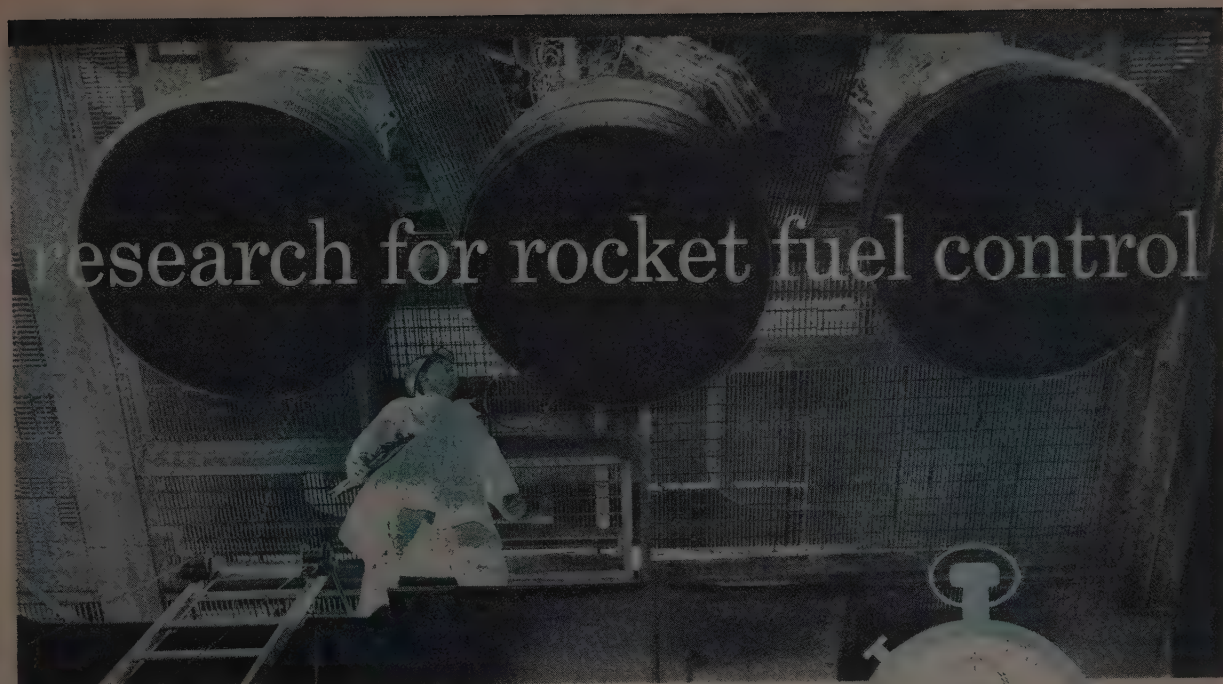
This type of antenna is easily fed by either co-ax or waveguide. It is also relatively insensitive to the ground plane.

#### Most butterfly scimitars linearly polarized

The coplanar scimitar is linearly polarized, but the orientation is different for all points in space. The butterfly scimitar is mostly linearly polarized (with a conical beam perpendicular to the ground plane). The rosebud scimitar has a very broad hemispherical beam that is linearly polarized near the ground plane and becomes circularly polarized as one approaches the axis perpendicular to the ground plane.

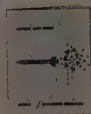
Similar to the scimitar are the exponential loop and valentine antennas, which are essentially two scimitars back to back. Their impedance characteristics are almost identical with those of the scimitar for comparable sizes, and they are just as admirably suited for integration into an airframe structure.

more on next page



## research for rocket fuel control

Pumps, turbines, cryogenic hardware and fuel systems—everything short of firing the rocket—will soon be tested by a CEC process control system. Working with dangerous propellants and limited time, the system will provide complete, automatic programming, rapid control, and data in 30 seconds. Write for the complete story in Bulletin CEC 3015-X10.



Systems Division

# CEC

**CONSOLIDATED ELECTRODYNAMICS** 300 No. Sierra Madre Villa, Pasadena, Calif.

*For employment opportunities  
with this progressive company,  
write Director of Personnel*



From a central block house, the operator controls and reads air pressure, exhaust temperature, turbine speed, flow rate, pump suction pressure, and receiver tank pressure. The system automatically corrects for rates of change of test parameters to insure maximum data in limited time.

Circle No. 35 on Reader Service Card in Product Review Section





*In Precision Machining—meet a man who gets results*

### **Picking up a spare or machining a part... accuracy typifies this General Mills craftsman**

Meet Tom Nelson, bowling enthusiast and General Mills' machinist with 12 years experience. At the bowling alley or at the plant, Tom's physical and mental capabilities make him an outstanding performer.

Like our other precision craftsmen, Tom works to extremely close tolerances. We've equipped him with the tools—lathes, mills, drills, grinders and many special purpose machines built to our specifications—to make close tolerance manufacturing a routine procedure. And we back his output with strict quality control to make doubly sure only perfect parts go into assembly.

Complementing our precision manufacturing facility are well staffed research and engineering laboratories. Together, Research, Engineering and Manufacturing work as a team to provide complete military systems and subsystems services.

**WORTH SENDING FOR**—new fact-packed booklet tells about the many ways we serve industry and the military. Send for your copy today. Address Dept. AF-12.

## **MECHANICAL DIVISION**

1620 Central Avenue, Minneapolis 13, Minnesota

*To wider worlds—through intensive research • creative engineering • precision manufacturing*

**Circle No. 36 on Reader Service Card in Product Review Section**



### **SPIRAL ANTENNAS . . .**

If the antennas are small (compared with a wavelength), they act essentially as transformers that excite the entire structure around them. If they are large, they have a fat lobe whose center is oriented in the direction of the feed points.

These antennas are widely used as feed structures for secondary apertures. They can be fed unbalanced either from a co-ax line by a so-called finite balun or parasitically from a waveguide.

Logarithmic periodic structures are fast becoming one of the most useful antenna designs. They have essentially constant impedance and highly stable patterns over bandwidths as great as 20:1. The patterns are bidirectional when the antennas are coplanar with non-planar construction they have a front-to-back ratio of about 12 db.

### **Relatively insensitive to cavity environment**

The non-planar antennas fire off the nose and are horizontally polarized when two elements are stacked vertically one above the other in a complementary manner. They can have any polarization—from linear to either right or left elliptical or circular—when stacked over a rectangular cone. Four or more units must be used, with suitable phase shifters or switches between them.

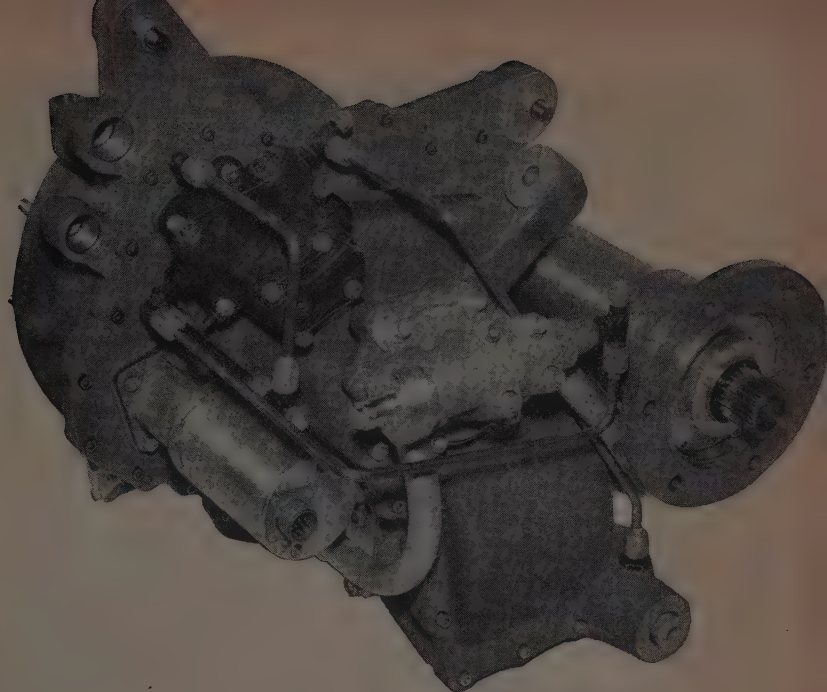
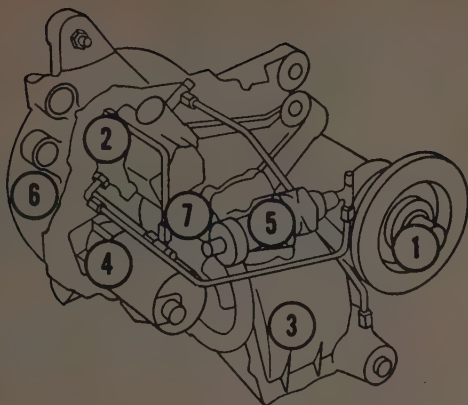
These antennas can have many form factors so long as Babinet's principle on complementary structures is properly observed. They are balanced but can be fed from a co-ax line with an infinitesimal balun.

Recent work at the University of Illinois indicates that these antennas are relatively insensitive to a cavity environment. The bandwidth that can be obtained from these antennas when they are mounted within a cavity is about two octaves.—End



Tom operates a precision jig borer in this picture, but he is an expert at every machine in the plant. Earlier in his career with us, he won the Minnesota Employer's Association award as the state's Outstanding Apprentice of the Year. He is active in community affairs, participates in many company activities. Tom Nelson—another of the many good reasons our customers say, "At General Mills, we get results."





**1 —INPUT SHAFT**

Accepts varying input speeds from 3800-7000 RPM.

**2 —GOVERNOR**

Maintains  $\pm 0.25\%$  steady state speed over 200° F temp. range,  $\pm 0.5\%$  for 400° F temp. range and 0.5 second maximum full load transient recovery time.

**3 —VARIABLE DISPLACEMENT PUMP/MOTOR**

Either pump or motor, depending on whether it is adding to or subtracting from drive speed.

**4 —OVERSPEED GOVERNOR**

Senses a predetermined excessive speed to prevent drive overspeeding.

**5 —MAIN SYSTEM RELIEF VALVE**

Overload protection for hydraulic system.

**6 —DIFFERENTIAL GEAR SECTION**

Ring, sun and planet gears. Also includes take-off gears for governors, scavenge and make-up pumps.

**7 —FIXED DISPLACEMENT MOTOR/PUMP**

Drives, or is driven by, sun gear to control output speed at 6000 rpm in response to fluid flow exchange with variable delivery unit.

## A SIGNIFICANT ADVANCEMENT—

# Differential Type Constant Speed Drive For Aircraft Alternators

Tests now in progress on this 60 kva Vickers Differential Type Constant Speed Drive are proving its outstanding performance. (See curves) It combines Vickers dependable hydraulic pumps and motors with planetary gearing to provide a more efficient and lighter "package" than drives now available.

The differential type constant speed drive is a direct engine-driven transmission that can be either engine pad mounted or universal shaft driven. It employs the "differential drive" principle wherein the planetary gear train is the principal power vehicle and the hydraulic components differentially add or subtract speed and power to maintain constant output speed. For further information, write for Bulletin A-5221.

Circle No. 37 on  
Reader Service Card  
in Product Review  
Section

## VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

### Aero Hydraulics Division

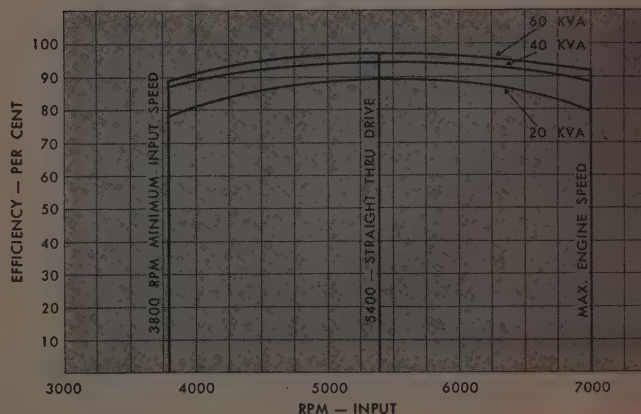
#### Engineering, Sales and Service Offices:

ADMINISTRATIVE and ENGINEERING CENTER

Department 1481 • Detroit 32, Michigan

TORRANCE, CALIFORNIA • 3201 Lemita Boulevard

P.O. Box 2003 • Torrance, California



Performance of Vickers 60 kva Differential Type Constant Speed Drive at three different loads. The high efficiency requires minimum support equipment for cooling with minimum penalty for high temperature operation (400°F oil temp.)





## Now Available in A-286 Stainless Steel **CHERRY AIRCRAFT LOCKBOLTS**

Designed especially for High Strength—High Temperature and liquid oxygen and other corrosive applications, Cherry Aircraft Lockbolts\* are now available in austenitic A-286 Stainless Steel.

Available for the aircraft industry in a wide range of diameters, grip lengths and head styles in A-286 . . . Cherry Lockbolts are also produced in Alloy Steel

and Aluminum.

Cherry Lockbolts are structural fasteners providing simplicity and speed of installation with uniform high tensile preloads.

Shop men like them.

For information on Cherry Aircraft Lockbolts, write Townsend Company, Cherry Rivet Division, P.O. Box 2157-P, Santa Ana, California.

\*Licensed under Huck patents RE22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

## CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

## Townsend Company

ESTABLISHED 1816 • NEW BRIGHTON, PA.

Circle No. 38 on Reader Service Card in Product Review Section



Special Report

Space/Aero Electronics



**BLACK BOXES** in the nose of this interceptor contain navcom and fire control gear. Common design mistake is to overbeef structural members to take care of mechanical "unknowns".

## Mathematical analysis for minimum weight and space envelope, top reliability

Airborne electronic equipment all too often is the victim of overdesign—because no careful computation was made of the static and dynamic loads to be expected in service. For efficient design and top reliability, a thorough analysis of shears, bending moments, vibrations, etc., is a must.

by **David Ehrenpreis**  
Consulting Engineer

**I**N THE mechanical design of airborne electronic and electromechanical gear, the margin of safety is a prime factor. It can make the difference be-

tween minimum and excessive weight and geometric envelope and between reliability and unreliability.

The margin of safety simply:

$$MS = F/f - 1,$$

where  $F$  is the allowable stress and  $f$  the actual stress. It's obvious that probability of failure is a function of  $MS$ .  $MS$  is negative, the mechanical or structural member will probably fail. If it is a large positive number, the equipment will most likely be over-weight and/or oversized.

Obviously, for efficient mechanical design, an optimum balance has to be struck between reliability and size and weight.



## Damping Analysis

Following the procedure outlined in this article, an analysis of a typical missile electronic equipment revealed these interesting results:

Increased damping is obtained through the use of a sandwich-type construction.

Increased damping is obtained by permitting the structure to vibrate elastically and deform at built-up joints.

Transmissibility at resonance, in the case of most electronic equipment, decreases as the natural frequency of the structural members increases.

Transmissibility at resonance for electronic equipment (except on gimballed structures) decreases with increased amplitude input at resonance excitation.

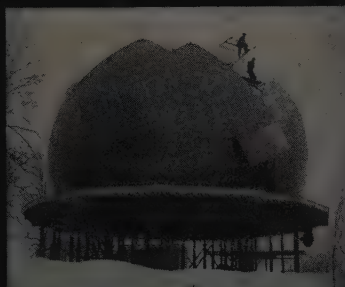
Allowable stresses for calculating MS can be found in published data.\* Actual stresses must be found by a rigorous mathematical analysis of the dynamic properties of the system and its environments.

Briefly, this analysis should determine such parameters as the required wall thickness of critical members, gimbals, castings, extrusions, and built-up formed members with the desired margins of safety against fatigue, shear, or permanent deformation. It should also determine the best vibration and shock isolation system, if a suspension system is needed. As the analysis proceeds, it will become obvious to the designer just where he can "shave off" weight and bulk without compromising reliability. Just such a procedure has been worked out and successfully used to find the dynamic properties and minimum weight and envelope of airborne electronic and electro-mechanic equipment.

Allowable stresses for most structural materials (aluminum, steels, and magnesium) are found in ANC-5 and for sandwich construction in airborne equipment racks and modules in ANC-23.

more on next page

# stitching together a giant radome



Radome designed and built by Long Sault Woodcraft Limited, St. Andrews East, Quebec, for the United States Air Force RADC.

Looking upward from the inside of the world's largest stressed skin sandwich radome built of translucent fiberglass panels, securely joined by hundreds of DUAL-LOCK fasteners.

Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

### Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
- Double-acting take-up provides great closing pressure, with minimum pressure on operating tool.

- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

**Write for catalog #1257.** Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



## SIMMONS FASTENER CORPORATION

1760 North Broadway, Albany 1, New York

See our catalog in Sweet's Product Design File

QUICK-LOCK • SPRING-LOCK • DUAL-LOCK • ROTO-LOCK • LINK-LOCK • HINGE-LOCK  
Circle No. 39 on Reader Service Card in Product Review Section



# The Typi

The regime is defined as the t of all dynamic matrices, re sion equations and distributi of masses and inertias nee to find the dynamic propertie the electronic (or electromechanical) equipment caused by ex tion in one axis.

The recursion equations de the deflection, slope, shear moment from substation to s station along one subsystem

A substation is a critical p along a subsystem of the eq ment.

A subsystem is a prim structural or mechanical mem of the electronic equipment.

In a typical case, it might b some 60 dynamic equations define a single regime. Th equations define, within the bounds of the subsystem, ternal rotation (F), internal be ing (H), internal shear (K), ternal moment (K'), exter moment (M), external shear ( external deflection (y) and ternal rotation (a).

For example, the equation the externally applied deflect (y<sub>a</sub>) at point "a", one of bounds of the subsystem i,  $y_a = a_b H_a^{ab} + Q_b H_a^{qb} + y_b H$  Here  $H_a$  is the internal resist deflection at "a";  $H_a^{ab}$ , the ternal deflection at "a" caus by a unit applied rotation

\*For typical dynamic equations in t regimes, see D. Ehrenpreis, "An sis and Theoretical Investigation of Military Electronic Missile- and Air- Borne Equipment," IRE National vention, March '58.

The first step in the pro dure is to set up a mathem ical model of the system un study. The model consists three mathematical regi defining for each of the th mutually perpendicular a the dynamic forcing funct

Each of the three regime made up of the defining re sion dynamic equations duced to linear algebr first-order, first degree fo dynamic matrices, and the cusion tables defining inputs, responses, natural quencies, damping charac isitics, deflections, rotati

CENTURY PRESSURE SWITCHES  
PERFORM WITH CONSTANT  
REPEATABLE ACCURACY

Anywhere



Gage — Absolute — Altitude or Differen-  
tial Types

There Is a Century Pressure Switch for  
Your Application



NEW CATALOG  
NOW READY

CENTURY ELECTRONICS  
& INSTRUMENTS, INC.

1341 N. UTICA • TULSA, OKLAHOMA



gime\*

a second bound of subsystems;  $a_b H_{ab}$ , the internal deflection at "a" caused by a unit deflection at "b", or the true internal deflection at "a" caused by the true rotation at "b";  $H_{ab}$ , the true internal deflection at "a" caused by the true shear at "b"; and  $y_b H_{ab}$ , the internal deflection at "a" caused by the true shear at "b". The equation for the external-applied bending moment ( $M_a$ ) at "a" is similar:

$$-M_a = 0 = a_b K'_{ab} + Q_b K'_{ab} + y_b K'_{ab}$$

where  $a_b K'_{ab}$  is the true internal moment at "a" caused by the rotation at "b";  $Q_b K'_{ab}$ , the internal moment at "a" caused by the true shear at "b"; and  $y_b K'_{ab}$ , the true internal moment at "a" caused by the deflection at "b".

Throughout the regime equations, the quantities  $y$ ,  $a$ ,  $Q$  and appear as non-zero coefficients in the dynamic matrices.  $H$ ,  $F$ , and  $K'$  are polynomials in terms of  $\omega$ , the natural frequency. Substitutions along the equipment's subsystems are analytically linked to each other by version equations.

It is a simple matter to plot error function vs assumed natural frequency on a digital computer. Where the error crosses the x-axis, the electronic equipment has a fundamental resonant frequency or asymptote.

Internal and external shears, internal and external bending moments, torsional shears and moments, thrusts, and elasticity deformations at all critical substations along each system.

Each potential design change appears as an "open parameter" and can be "plugged" into the matrices, recursion equations, or recursion tables of the mathematical model. The solution then reveals the effects of the parameter changes on reliability and dynamic performance.

more on next page

## ...NEWS IS HAPPENING AT NORTHROP

### OPERATIONAL NOW! NORTRONICS UNIVERSAL DATICO TO CHECK OUT ADVANCED MISSILE SYSTEMS!

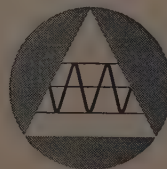
**READY NOW!** The first and only universal automatic checkout equipment in production is Nortronics' Universal Datico. Standardized, self-checking test equipment, readily adaptable to any missile system or group of systems, Universal Datico is a single system of automatic evaluation equipment available for support of advanced operational missiles. Other production contracts include checkout applications to U.H.F. equipment and autopilot sub-systems.

**PERFORMANCE PROVED.** Datico has logged thousands of hours of reliable performance during which its speed and adaptability from one system to another have been demonstrated. Its rapid, unerring, Hi-Go-Lo evaluation of existing systems indicates its applicability to future systems as well as to today's. It quickly locates malfunction of the system or any sub-system element down to piece parts and records its findings on printed tape.

**TIME-MANPOWER-DOLLARS.** Datico saves all three. No need for costly, time-consuming research and development. Datico is available now for today's requirements. Application of Datico to your problem can mean savings up to 75% in manpower plus a dividend in reduced skill-levels required; savings up to 90% in checkout time; and 50% in acquisition cost.

**TOMORROW'S DATICOS**—Nortronics' continuing development program, combined with the management and engineering foresight which created Datico in time for today's weapons, is now developing advanced Daticos for tomorrow's weapons. These new checkout devices will incorporate even greater speed and such features as evaluation of total system degradation without sacrificing reliability and relative simplicity.

If you have a checkout problem...if you have checkout requirements for any system or level of a system, call Nortronics today, or write Chief Applications Engineer, Dept. 2003-F Nortronics, A Division of Northrop Aircraft, Inc., 500 East Orangethorpe, Anaheim, California.



**NORTRONICS**  
A Division of Northrop Aircraft, Inc.



# Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

One of the ways to judge a skilled craftsman is by the tools he uses. They're invariably the best he can find — chosen to lighten his work, sharpen his skills. And, if the craftsman is a draftsman, they are, more often than not, products of K&E.

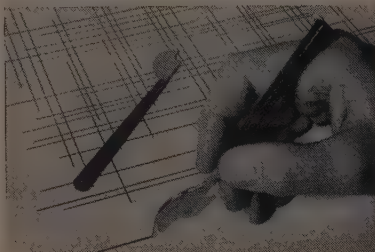
It may be that some of these products have escaped your attention (after all, we offer something over 8000 items). That's why we suggest you pay a visit to your K&E dealer whenever you can. It's a liberal education on what's new — as well as what's tried and true — in drafting equipment.

You'll find many products like these which can be highly useful in your work...

## K&E "Quick Set" Bow Compass

The most remarkable feature of this compass is the speed and ease with which you can change settings—from diameters of 12 inches to 1/16 inch. With one hand, you can increase or decrease radii instantly and exactly. To go from small to larger radius, just press a spring release, and the legs will

leg pencil compass, and the N1070 combination with interchangeable pen and pencil inserts. Both come with a box containing leads and spare needles. And with the N1070, a pen handle is provided for the pen insert which permits its use as a ruling pen. The compass can also be used as a divider by substituting one of the spare needle points for the lead in the pencil insert.



## Marathon® Ruling Pens

K&E Marathon Long Line and Wide Line Ruling Pens (1092) hold an extra large

ink supply — draw lines up to eight times longer than ordinary ruling pens. And because they are pre-set, line widths are always uniform, easy to match with complete accuracy. Ink flow is regular and even, lines are always sharp and clean edged.

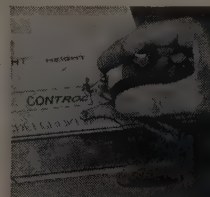
An important feature of K&E Marathon Ruling Pens is that they will *not* leak. They can be laid on the work surface without risk of ink flowing out. That means you can fill several pens of different widths, use them as freely as you'd use pencils. They're easy to clean, too.

K&E Marathon Long Line Ruling Pens are available individually in line widths of .006, .009, .013, .020 inch — or in sets of three pens in line widths of .009, .013, .020 inch in a Leatherite case. Marathon Wide Line Ruling Pens come in line widths of .030 and .060 inch.

## Leroy® Height and Slant Control Scriber

A versatile new Leroy scriber is now available which greatly expands the variety of lettering possible from a standard Leroy template.

Now, with the new Height and Slant Control Scriber (3237-12), you can form characters from vertical to slanting at any angle up to 45° forward. You can vary height from 60% to 150% of the size of letters on the template used. The width of letters remains the same.



Combinations of height and slant can be set quickly and easily. You just loosen the knob, move the scriber arm to the desired combination of height and slant, and tighten. That's all there is to it.

Stop in to see your nearest K&E dealer and ask to see these three products—small, perhaps, but mighty handy in the drafting room. Or drop us a line by mailing the coupon below...



expand automatically. Stop approximately where you want, and make precise adjustments with a micrometer screw. To go from large to small, simply squeeze the legs of the compass together, then adjust precisely.

The K&E Quick Set combines the rigidity and precise adjustment of a standard bow compass, the simplicity and speed of a friction type compass, plus the finger tip control of K&E's unique design. You have to try the Quick Set to appreciate it fully. Two types are available. The N1071 fixed

## DESIGN ANALYSIS . . .

Typical open parameters now might be material thickness, supporting technique, stiffness, and damping. Limiting factors, as it is expected, it will be possible to plug in cost estimates, schedule time, fabricability, serviceability, and availability as open parameters.

The forcing functions for military aircraft load factor determination include takeoff, landing, catapult, flight maneuver, gust, and buffeting. Specs for missile and speed aircraft attempt to define peak probable load conditions as envelopes of acceleration and plots of amplitude vs frequency of excitation.

Mil-E-5270, Mil-E-5400 and special airborne electronic equipment specs give the required test procedures for onance search, cycling, resonance dwell phases. Additional test procedures include sudden impulse shock and sustained acceleration tests.

The most difficult phase of the test is the dwell at the resonant point frequency on each axis. At resonance, high amplification of structural frames of electronic equipment cause permanent deformations and fatigue failures.

High Mach missiles experience vibration load inputs at high frequencies. Transportation and shipping loads for electronic equipment are not shock loads and low frequency sustained vibration loads. Gun fire loads are high intensity low frequency steady-state vibratory loads, with random shock pulses added. Flight maneuver loads are generally treated as sustained accelerations. Takeoff loads are considered by many as random vibrations and are often simulated in tests as a cycling procedure from five to 1500 cps varying acceleration and amplitude.

The actual stress is determined from the analysis of each equipment member.

When rotation and deflection

KEUFFEL & ESSER CO., Dept. AA-1 Hoboken, N. J.

I'd like more information on:

- ☐ K&E Quick Set Compass ☐ Leroy Height and Slant Control Scriber  
☐ Marathon Ruling Pens  
☐ Please send me the name and address of my nearest K&E Dealer.

Name & Title \_\_\_\_\_

Company & Address \_\_\_\_\_



affect performance, margin of safety must be found in the members that might be exposed to these effects. The analysis determines—for each critical substation of every sub-member—orders of magnitude deflection, rotation stress, bending moment, thrust, shear, torsional moment, and allowable buckling. Also, it determines natural frequencies, responses at inputs, and damping. The analysis is used at three stages of the electronic or electromechanical equipment's development:

1) *Preliminary Design*—A theory potential and kinetic energy relationship analysis may be made to find orders of magnitude of critical deflections, rotations, stress, natural frequencies, and responses at critical substations in the network. The study should determine optimum geometric shapes of every structural and mechanical member for several different layouts of alternate designs.

2) *Final Design and Design Status*—A rigorous, three-time analytic approach using digital computer is recommended. The precise actual stresses in combined bending, torsion, shear, thrust, and buckling as well as the allowable stresses in fatigue and buckling must be analyzed and compared to determine margin of safety. All critical stresses and their harmonics should be investigated to make sure no members are overstressed and all members have proper MS against failure or permanent deformation.

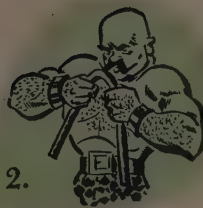
3) *Failure To Meet Specs*—If the equipment fails to meet the dynamic and stress analysis requirements of Mil-272A, Mil-E-5400, or Mil-422, this analysis is optimum. It may be applied to determine quick fixes at critical points to add damping at resonance or revise the critical stresses of natural frequency to reduce deflections, rotations, and stresses.—End



6.



1.



2.



5.



4.



3.

## \*Write your own Specs for your Perfect Drawing Pencil

When you send out bids for a bridge, a power station or a consumer product, you demand rigid adherence to your specifications. Why not with your drawing pencil, the most important working tool of your profession? Here is our set of specs—you may have your own ideas. See if we agree.

1. **SMOOTHNESS**—The pencil lead must be absolutely free of grit and hard spots. It must glide across the paper like an Olympic skater on ice.

2. **STRENGTH**—The pencil lead must be strong, without brittleness or splintering, and able to take needle-point sharpness in all drafting degrees, yet withstand firm drawing pressure.

3. **UNIFORMITY**—The pencil lead must have a steadfast consistency of hardness in each degree, pencil after pencil, lead after lead—dependable grading in a full range of 20 degrees, 8B to 10H.

4. **BLACKNESS**—The pencil lead must have pure graphite-saturated consistency, assuring positive opacity. It must not be treated with foreign oily

substances to give the illusion of black. Natural graphite blackness eliminates greasiness and reduces stains and smudges to the absolute minimum. Erasing must be quick and easy, and leave no ghosts.

5. **DENSITY**—The pencil lead must lay down solid opaque graphite-packed non-feathering lines in every degree, from the softest to the hardest drafting grades, providing maximum adhesion to give long-lasting age-resisting originals.

6. **REPRODUCTION**—The pencil drawing or tracing must produce clear, sharp reproductions, even after hundreds of trips through the reproduction machine.

Professional designers, engineers, architects and draftsmen by the tens of thousands, in every country on earth, will instantly recognize these specs as a description of A.W.FABER CASTELL—the pencil with Black Gold graphite—*natural* graphite that tests out at more than 99% pure carbon. The inference is plain. Call your Dealer today.

Castell Leads and Pencils draw on all surfaces, including Mylar-based Polyester drafting films. Gives perfect lines, easy to erase—excellent reproduction.



Choose from:

- #9000 CASTELL Pencil
- #9007 CASTELL with Eraser
- #9800SG LOCKTITE TEL-A-GRADE Holder with new functional spiral grip and degree indicating device.
- #9030 CASTELL Refill Lead matching #9000 pencil in quality and grading, packed in reusable plastic tube with gold cap.

Other styles and colors of pencils, holders and refill leads.



A.W.FABER-CASTELL Pencil Co., Inc.  
Newark 3, N. J.

PRODUCT OF NEARLY 200 YEARS OF UNINTERRUPTED EXPERIENCE.

Circle No. 42 on Reader Service Card in Product Review Section



# design digest

## Parami scores missiles in real time

PARAMI (Parsons Active Ring-Around Miss Indicator), produced by The Ralph M. Parsons Co., 151 S. De Lacey Ave., Pasadena, Calif., is an electronic miss distance indicator that gives you a real-time digital record of miss distances from 10 to 3000 ft range. It links target and missile transponders through wide band, pulse-modulated distanced data on two UHF carriers. The stronger target transponder telemeters data to the ground station. Fast ground-to-target calibration sharpens system accuracy before the test run. Among the missiles equipped with Parami are Nike-Ajax and -Hercules, Falcon, Genie, and Sidewinder.

by Bernard Kovit, Assistant Electronics Editor

**RINGING FREQUENCY METHOD** — Target transponder transmits a signal pulse that is received in missile on carrier frequency  $f_1$  (252 mc) and retransmitted on carrier  $f_2$  (291 mc). The signal is picked up on  $f_2$  by the target receiver and retransmitted on  $f_1$ . Information frequency appears as amplitude modulation on each stable carrier. With enough gain in the system, the signal passes around the loop in a regenerative manner. Ringing frequency depends on the fixed electronic delay ( $t_e$ ) in the equipment and the variable delay of the radio gap between the transponders. The latter is the information we want to get—as precisely as possible. The formula used to obtain this value is:

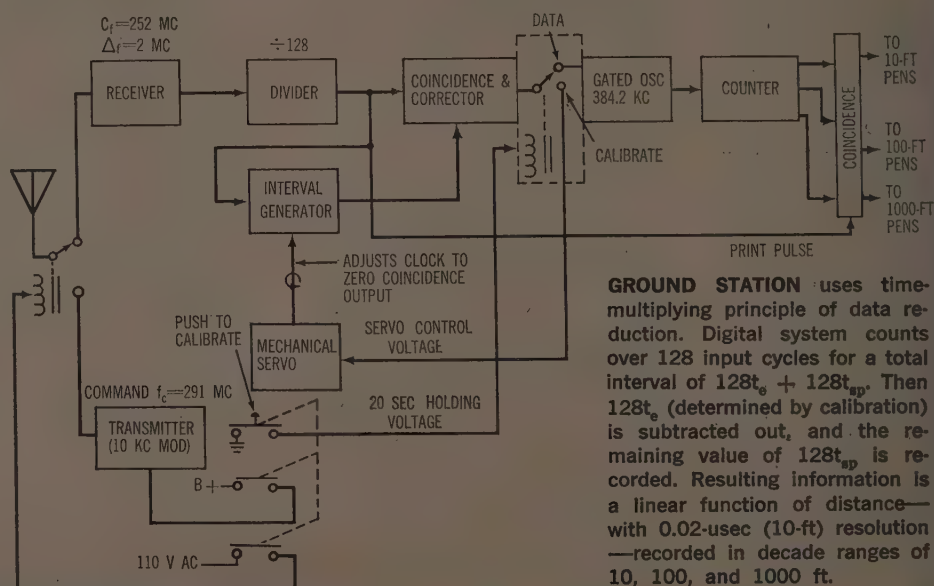
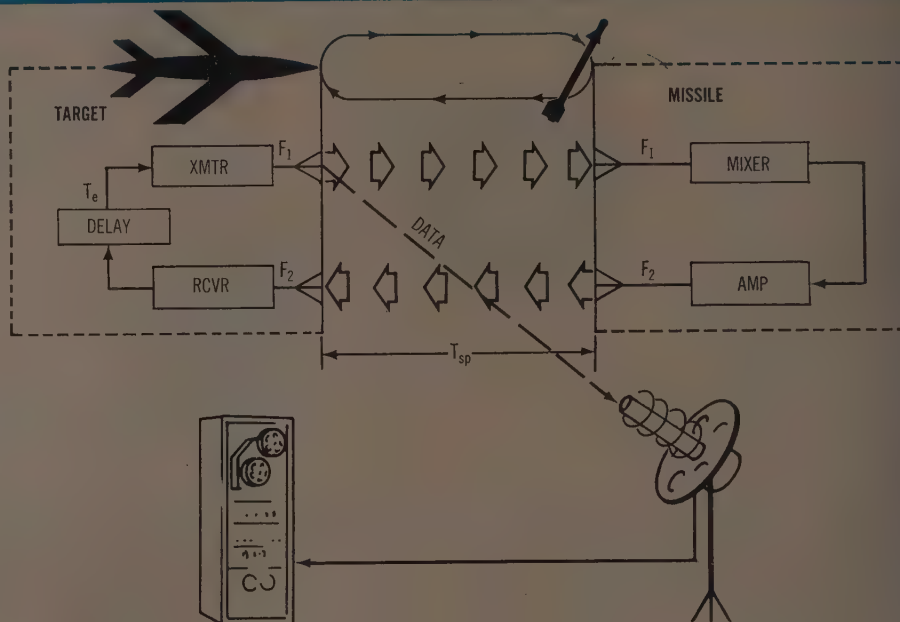
$$f_{data} = \frac{1}{t_e + 2R/c}$$

where  $2R$  represents the round-trip distance between the transponders and  $c$  the speed of light.

The ground station is made up of a five-foot-high standard electronics rack and a four-foot-high helical antenna. A simple computer subtracts the two periods of electronic delay and counts in tens of feet exactly half of the round-trip radio delay ( $t_{sp}$ ) giving us the miss distance we're looking for. The recorder tape then shows the radial separation of missile and target to 4990 ft in 10-ft increments.

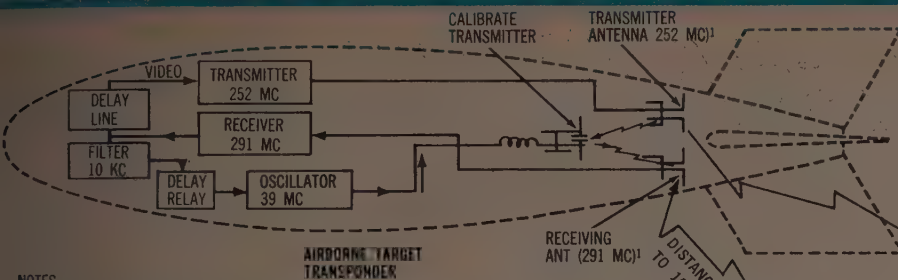
### Parami Spec Summary

- Operating range: 10-3000 ft
- Operating frequencies: 252 and 291 mc
- System accuracy: 5-10 ft miss distance error
- Relative velocity: over 5000 fps
- Range of missile sizes: .50 cal bullet to large guided missiles
- Power output: target transmitter, 100W; peak; missile transponder, 0.1 W (3000-ft version)
- Antenna beamwidth: about 40 deg
- Form of data: tens of feet, real time; time to get minimum miss distance and interpret record should not exceed one minute, says Parsons
- Data sampling rate: 195.3 samples per sec at 10 ft; 149.6 samples per sec at 3000 ft



**GROUND STATION** uses time-multiplying principle of data reduction. Digital system counts over 128 input cycles for a total interval of  $128t_e + 128t_{sp}$ . Then  $128t_e$  (determined by calibration) is subtracted out, and the remaining value of  $128t_{sp}$  is recorded. Resulting information is a linear function of distance—with 0.02-usec (10-ft) resolution—recorded in decade ranges of 10, 100, and 1000 ft.

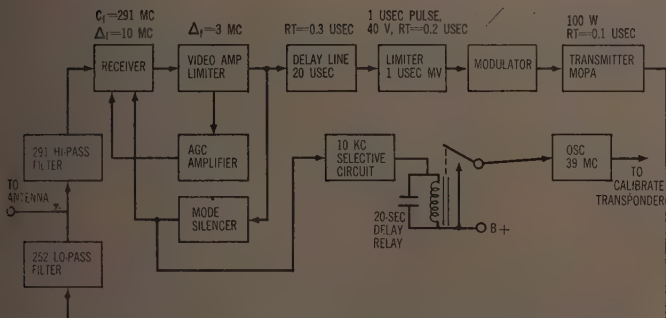




**CALIBRATE SYSTEM**—At any time before intercept, 291-mc ground command transmitter sends out 10-kc, 1-sec pulse train to target. Ten-kc bandpass filter in target receiver output actuates 20-sec delay relay that energizes 39-mc oscillator. With calibrate loop closed, target system rings at near-zero-distance frequency. Ground receiver accepts 252-mc pulse, modulated with  $f = 1/t_{\text{cal}} = 50 \text{ kc}$ , for 20 seconds and inserts it in recorder.

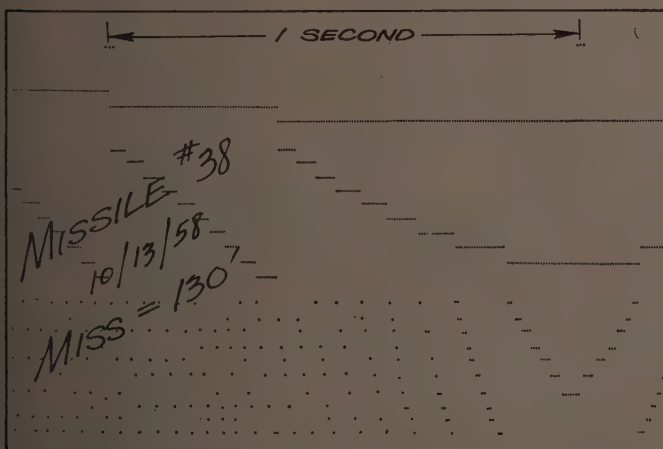
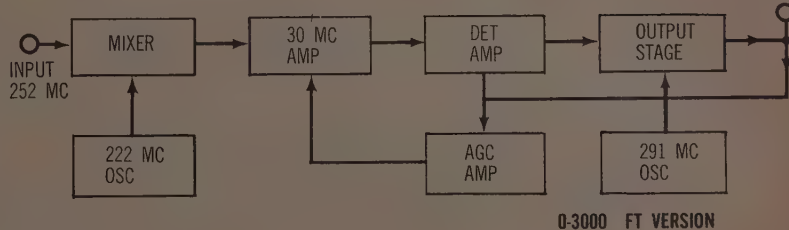
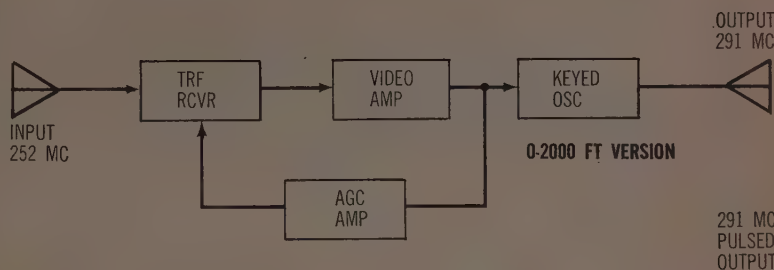
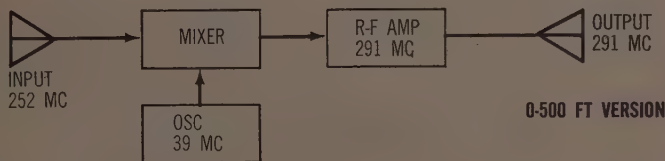
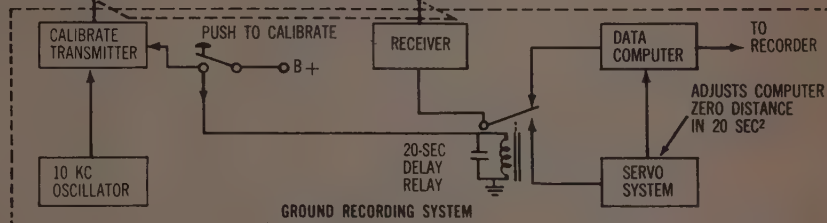
NOTES:

- (1) DUAL ANTENNAS USED TO CLARIFY EXPLANATION (2) MECHANICAL SERVO IS OPTIONAL; MAY BE MANUALLY SET



**▲ TARGET TRANSPONDER** — Basic components are wide band receiver, delay line, and transmitter. Receiver is six-stage grounded-grid, TRF type. It is delay-stable  $\pm 0.008 \text{ usec}$  from 20 uv to 0.1 V over a 4-mc band centered at 291 mc. AGC handles intercept speeds up to 3000 fps. By including a simple calibrate transponder mounted within two feet of the main unit, Parsons makes it possible to calibrate out any delay variables.

**MISSILE TRANSPONDER**—To fit wide range of missile sizes (from smaller than Mighty Mouse to bigger than Nike-Hercules), Parsons uses three basic types. Simplest is a low gain (20 db) unit for short ranges (0-500-ft version). Most complex is 0-3000-ft unit with delay stability of  $\pm 0.01 \text{ usec}$ . Its circuitry resembles that of a typical beacon. The third transponder is used for smaller, higher speed missiles than the long range unit.



**INTERCEPT RECORD**—Facsimile was made from an actual Parami flight record. Notations "Missile #38..." were made by ground station operator. Using a scale

to identify traces, operator reads off distance of closest approach. Missile's speed can be found by converting distance traversed in one second to rate.

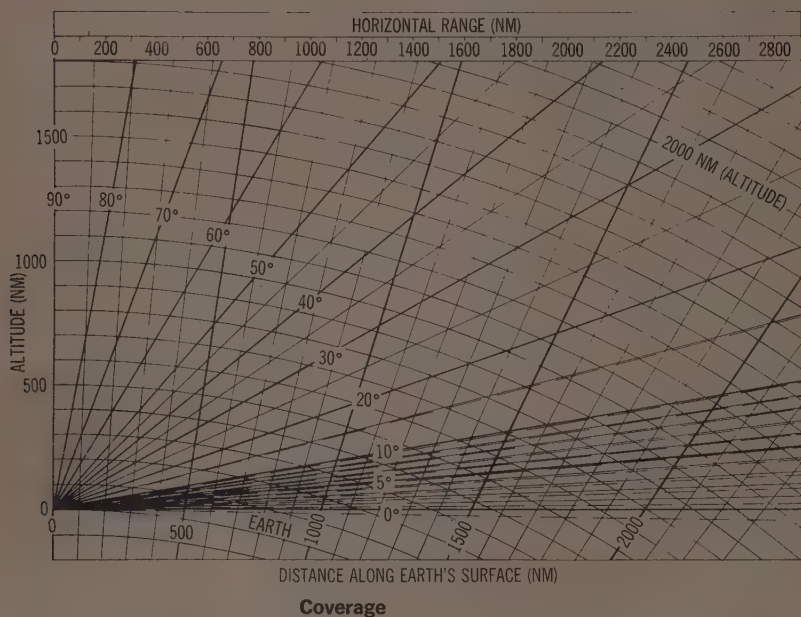
### Frequency MDI vs Other Types

	CW Doppler	Phase Comparison	Frequency
Accuracy	5-10 per cent	about $\lambda_m/100$	5 ft
Ambiguity	none	$\pm \lambda_m/2$	none
Missile equipment	several tubes	several tubes	several tubes
Telemetry needed	precise phase frequency	precise phase	none
Multipath rejection	none	depends on bandwidth	depends on bandwidth
Data reduction	usually several hours	real time	real time

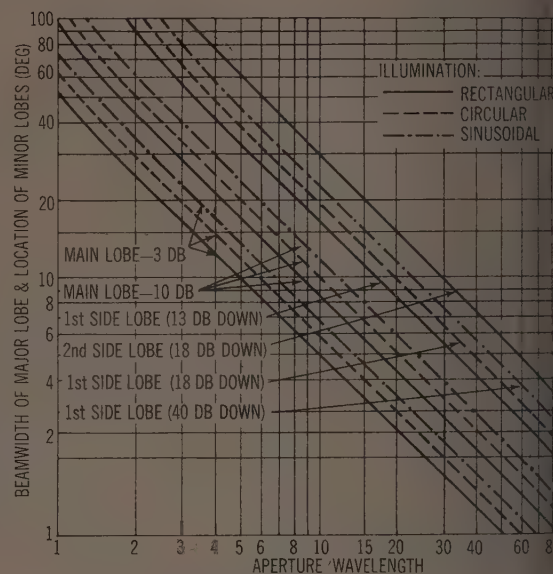




## Radar parameters

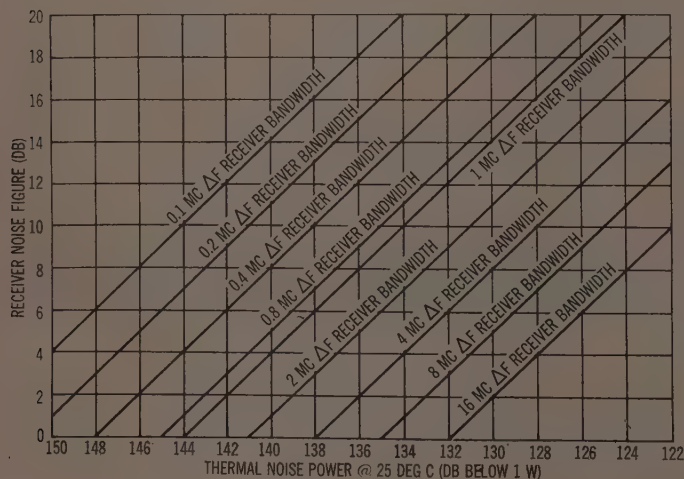


NOTE: Dashed lines show elevation angles corrected for atmospheric refraction according to observations by McCready, Pawsey, and Payne-Scott at 200 mc.



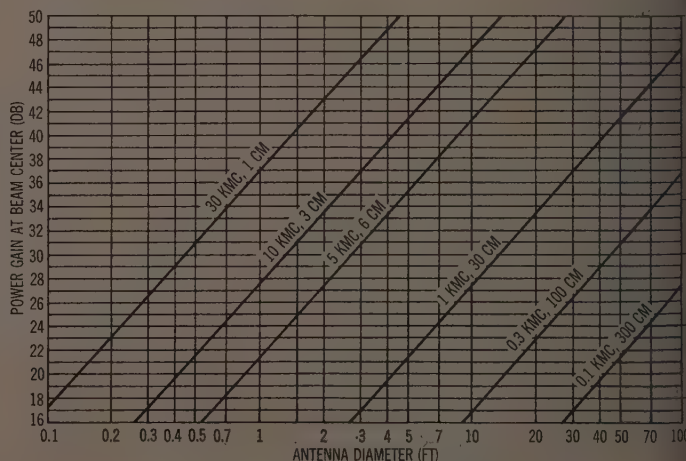
Beam Patterns

NOTE: Both aperture and wavelength are given in feet. For wavelength, this value is found dividing 983 by frequency (in megacycles).



Receiver Noise

These graphs are from "1959 Data Book," Defense Electronics Div., General Electric Co., Electronics Park, Syracuse, N.Y.

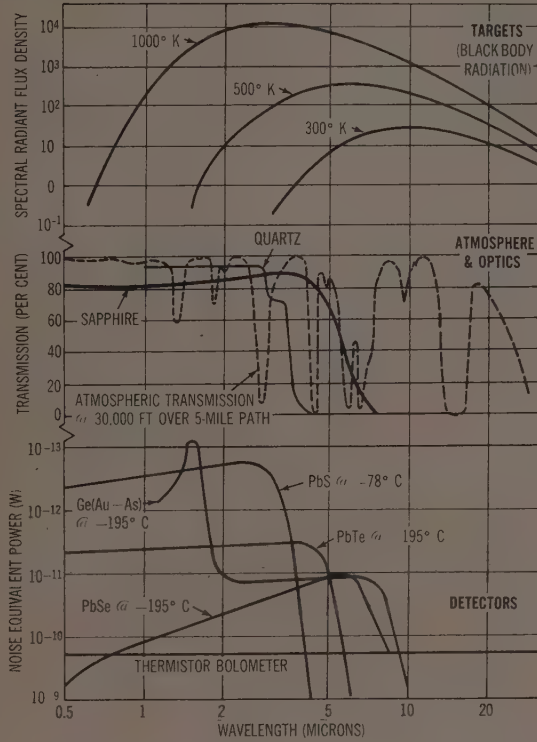
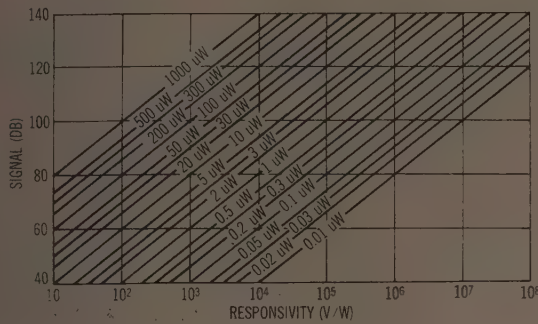
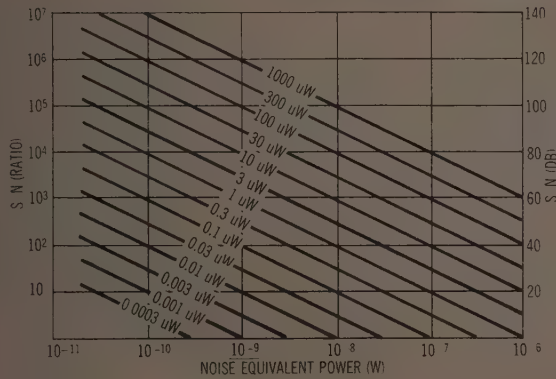


Gain and Beamwidth of Circular Parabolic Reflectors

NOTE: Based on 55 per cent power in main lobe.



## Infrared system parameters



Detector, Target and Atmosphere & Optics Curves

S/N vs NEP and Signal vs Responsivity  
for Various Incident Radiant Fluxes

The graphs on S/N vs NEP and signal vs responsivity are from "Infratron Lead Sulfide Photoconductors" (Technical Bulletin 2), Infrared Industries, Inc., P.O. Box 42, Waltham 54, Mass. The third graph is from "1959 Data Book," Defense Electronics Div., General Electric Co., Electronics Park, Syracuse, N.Y.

## Conversion of decibels to degrees

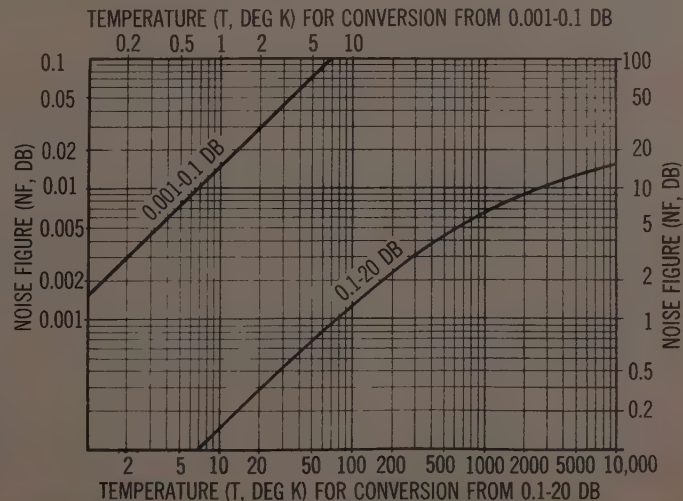
THIS Graph for the conversion of noise figure in decibels to effective noise temperatures in degrees is based on the formula:

$$NF = 1 + T/290, \text{ or } T = 290(NF - 1).$$

Noise figures were taken as power ratios in the calculation of the Graph. For example, a

noise figure of three decibels represents a ratio of 2.  $NF = 1$  therefore equals 1. Inserted in the second equation above, this gives a value of 290 for  $T$ .

Prepared for SPACE/AERONAUTICS by Albert T. Isaacs, Stanford Electronics Laboratories, Stanford U., Stanford, Calif.







## Atmospheric attenuation of space communication

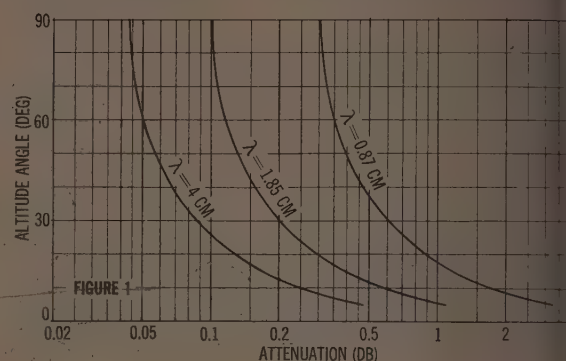
FOR the past 12 years, Collins Radio has been engaged in radio astronomy research. As part of this program, atmospheric attenuation has been measured with radio telescopes and sextants operating at wavelengths of 0.87 and 1.85 cm (34.5 and 16.2 kmc).

Much of the data was gathered by a combined 0.87-cm radio telescope-sextant that continuously records received

power while it automatically tracks the sun. Atmospheric attenuation can be found from the power reduction as the sun sets. For later, additional measurements, a 1.85-cm radio telescope was slaved to the 0.87-cm sextant.

To explain the experimental attenuation data, a theory was developed on the basis of the quantum mechanics of molecu-

more on page 76



## Gyro conversion tables

### ANGULAR MOMENTUM

Given Units	Required Units	lb-sq ft/sec	lb-in.-sec.	oz-sq in./sec	oz-in.-sec	slug-sq ft/sec	g-cm <sup>2</sup> /sec	kg-m <sup>2</sup> /sec	dyne-cm-sec	new-m-sec	oz-sq in.-rpm	g-cm <sup>2</sup> -rpm
	lb-sq ft/sec	1	$3.7297 \times 10^{-1}$	2304	5.9675	$3.1081 \times 10^{-3}$	$4.2140 \times 10^4$	$4.2140 \times 10^{-3}$	$4.2140 \times 10^4$	$4.2140 \times 10^{-3}$	$2.2002 \times 10^4$	$4.0241 \times 10^4$
	lb-in.-sec	2.6812	1	$6.1775 \times 10^3$	16	$8.3333 \times 10^{-3}$	$1.1299 \times 10^4$	$1.1299 \times 10^{-1}$	$1.1299 \times 10^4$	$1.1299 \times 10^{-1}$	$5.8990 \times 10^4$	$1.0790 \times 10^4$
	oz-sq in./sec	$4.3403 \times 10^{-4}$	$1.6188 \times 10^{-4}$	1	$2.5901 \times 10^{-3}$	$1.3490 \times 10^{-3}$	$1.8290 \times 10^3$	$1.8290 \times 10^{-3}$	$1.8290 \times 10^3$	$1.8290 \times 10^{-3}$	9.5493	$1.7466 \times 10^4$
	oz-in.-sec	$1.6757 \times 10^{-1}$	$6.250 \times 10^{-2}$	$3.8608 \times 10^3$	1	$5.2082 \times 10^{-3}$	$7.0615 \times 10^4$	$7.0615 \times 10^{-3}$	$7.0615 \times 10^4$	$7.0615 \times 10^{-3}$	$3.6869 \times 10^3$	$6.7435 \times 10^3$
	slug-sq ft/sec	$3.2174 \times 10$	12	$7.4129 \times 10^4$	192	1	$1.3558 \times 10^7$	1.3558	$1.3558 \times 10^7$	1.3558	$7.0786 \times 10^4$	$1.2947 \times 10^4$
	g-cm <sup>2</sup> /sec	$2.3730 \times 10^{-8}$	$8.8506 \times 10^{-7}$	$5.4675 \times 10^{-3}$	$1.4161 \times 10^{-3}$	$7.3757 \times 10^{-3}$	1	$10^{-7}$	1	$10^{-7}$	$5.2211 \times 10^{-3}$	9.5493
	kg-m <sup>2</sup> /sec	$2.3730 \times 10$	8.8506	$5.4675 \times 10^4$	$1.4161 \times 10^3$	$7.3757 \times 10^{-1}$	$10^7$	1	$10^7$	1	$5.2211 \times 10^3$	$9.5493 \times 10^3$
	dyne-cm-sec	$2.3730 \times 10^{-8}$	$8.8506 \times 10^{-7}$	$5.4675 \times 10^{-3}$	$1.4161 \times 10^{-3}$	$7.3757 \times 10^{-3}$	1	$10^{-7}$	1	$10^{-7}$	$5.2211 \times 10^{-3}$	9.5493
	new-m-sec	$2.3730 \times 10$	8.8506	$5.4675 \times 10^4$	$1.4161 \times 10^3$	$7.3757 \times 10^{-1}$	$10^7$	1	$10^7$	1	$5.2211 \times 10^3$	$9.5493 \times 10^3$
	oz-sq in.-rpm	$4.5451 \times 10^{-3}$	$1.6952 \times 10^{-3}$	$1.0472 \times 10^{-1}$	$2.7123 \times 10^{-4}$	$1.4127 \times 10^{-3}$	$1.9153 \times 10$	$1.9153 \times 10^{-3}$	$1.9153 \times 10$	$1.9153 \times 10^{-3}$	1	$1.8290 \times 10^4$
	g-cm <sup>2</sup> -rpm	$2.4850 \times 10^{-7}$	$9.2680 \times 10^{-8}$	$5.7254 \times 10^{-4}$	$1.4829 \times 10^{-3}$	$7.7236 \times 10^{-3}$	$1.0472 \times 10^{-1}$	$1.0472 \times 10^{-3}$	$1.0472 \times 10^{-1}$	$1.0472 \times 10^{-3}$	$5.4675 \times 10^{-3}$	1

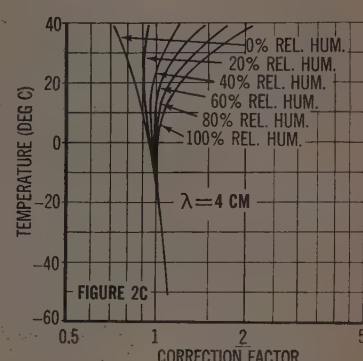
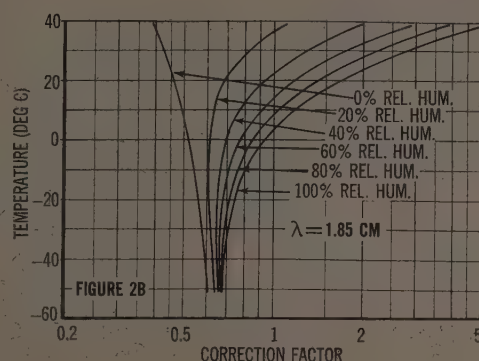
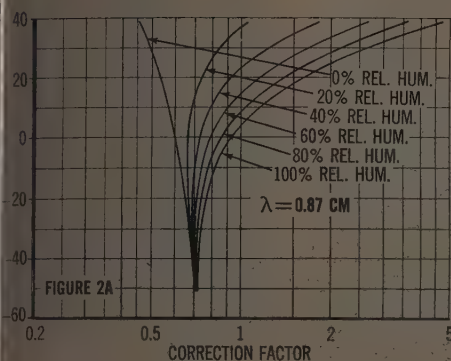
\*To find required units, multiply by the listed factors.

### ANGULAR VELOCITY

Given Units	Required Units	deg/min	deg/hr	rad/sec	mils/sec	min/sec	rpm	min/hr	mils/hr
	deg/min	1	60	$2.90888 \times 10^{-4}$	$2.90888 \times 10^{-1}$	1	$2.77778 \times 10^{-3}$	3600	$1.04720 \times 10^3$
	deg/hr	$1.66667 \times 10^{-2}$	1	$4.84814 \times 10^{-6}$	$4.84814 \times 10^{-3}$	$1.66667 \times 10^{-2}$	$4.62963 \times 10^{-3}$	60	$1.74533 \times 10^1$
	rad/sec	$3.43775 \times 10^3$	$2.06265 \times 10^4$	1	$10^3$	$3.43775 \times 10^3$	9.54930	$1.23759 \times 10^7$	3,600,000
	mils/sec	3.43775	$2.06265 \times 10^3$	$10^{-3}$	1	3.43775	$9.54930 \times 10^{-3}$	$1.23759 \times 10^4$	3600
	min/sec	1	60	$2.90888 \times 10^{-4}$	$2.90888 \times 10^{-1}$	1	$2.77778 \times 10^{-3}$	3600	$1.04720 \times 10^3$
	rpm	360	21600	$1.04720 \times 10^{-1}$	$1.04720 \times 10^3$	360	1	1,296,000	$3.76991 \times 10^4$
	min/hr	$2.77778 \times 10^{-4}$	$1.66667 \times 10^{-3}$	$8.08023 \times 10^{-8}$	$8.08023 \times 10^{-3}$	$2.77778 \times 10^{-4}$	$7.71605 \times 10^{-7}$	1	$2.90888 \times 10^{-1}$
	mils/hr	$9.54930 \times 10^{-4}$	$5.72958 \times 10^{-3}$	$2.77778 \times 10^{-7}$	$2.77778 \times 10^{-4}$	$9.54930 \times 10^{-4}$	$2.65258 \times 10^{-6}$	3.43775	1

\*To find required units, multiply by the listed factors.





## MOMENT OF INERTIA

Required Units*	lb-sq ft	oz-sq ft	lb-sq in.	oz-sq in.	slug-sq ft	g-cm <sup>2</sup>	kg-m <sup>2</sup>	new-m <sup>2</sup>	dyne-cm <sup>2</sup>
lb-sq ft	1	16	144	2304	$3.1081 \times 10^{-3}$	$4.21401 \times 10^3$	$4.21401 \times 10^{-3}$	$4.13253 \times 10^{-1}$	$4.13253 \times 10^8$
oz-sq ft	$6.250 \times 10^{-2}$	1	9	144	$1.9426 \times 10^3$	$2.63376 \times 10^4$	$2.63376 \times 10^{-3}$	$2.58283 \times 10^{-2}$	$2.58283 \times 10^7$
lb-sq in.	$6.94444 \times 10^{-3}$	$1.11111 \times 10^{-1}$	1	16	$2.1584 \times 10^{-4}$	$2.92640 \times 10^3$	$2.92640 \times 10^{-4}$	$2.86982 \times 10^{-3}$	$2.86982 \times 10^6$
oz-sq in.	$4.34028 \times 10^{-4}$	$6.94444 \times 10^{-3}$	$6.250 \times 10^{-2}$	1	$1.3490 \times 10^{-3}$	$1.82900 \times 10^3$	$1.82900 \times 10^{-3}$	$1.79364 \times 10^{-4}$	$1.79364 \times 10^4$
slug-sq in.	$3.2174 \times 10^{-5}$	$5.1478 \times 10^{-2}$	$4.6331 \times 10^{-3}$	$7.4129 \times 10^{-4}$	1	$1.3558 \times 10^7$	1.3558	$1.3296 \times 10$	$1.3296 \times 10^{18}$
g-cm <sup>2</sup>	$2.37303 \times 10^{-8}$	$3.79686 \times 10^{-3}$	$3.41717 \times 10^{-4}$	$5.46747 \times 10^{-3}$	$7.3757 \times 10^{-8}$	1	$10^{-7}$	$9.80665 \times 10^{-7}$	$9.80665 \times 10^3$
kgm-met <sup>2</sup>	$2.37303 \times 10^{-10}$	$3.79686 \times 10^{-5}$	$3.41717 \times 10^{-6}$	$5.46747 \times 10^{-4}$	$7.3757 \times 10^{-11}$	$10^{-7}$	1	9.80665	$9.80665 \times 10^6$
newton-met <sup>2</sup>	2.41982	$3.87172 \times 10$	$3.48454 \times 10^2$	$5.57527 \times 10^3$	$7.5211 \times 10^{-2}$	$1.01972 \times 10^4$	$1.01972 \times 10^{-1}$	1	$10^8$
dyne-cm <sup>2</sup>	$2.41982 \times 10^{-9}$	$3.87172 \times 10^{-8}$	$3.48454 \times 10^{-7}$	$5.57527 \times 10^{-6}$	$7.5211 \times 10^{-11}$	$1.01972 \times 10^{-4}$	$1.01972 \times 10^{-10}$	$10^{-10}$	1

\*To find required units, multiply by the listed factors.

## TORQUE

Required Units*	dyne-cm	newton-meters	oz-in.	ft-lb	in-lb	oz-ft	g-cm
dyne-cm	1	$10^{-7}$	$1.41612 \times 10^{-8}$	$7.37562 \times 10^{-3}$	$8.85074 \times 10^{-7}$	$1.18010 \times 10^{-6}$	$1.01972 \times 10^{-3}$
newton-meters	$10^7$	1	$1.41612 \times 10^2$	$7.37562 \times 10^{-1}$	8.85074	$1.18010 \times 10$	$1.01972 \times 10^4$
oz-in.	$7.06156 \times 10^4$	$7.06156 \times 10^{-3}$	1	$5.20833 \times 10^{-3}$	$6.250 \times 10^{-2}$	$8.33333 \times 10^{-2}$	$7.20075 \times 10$
ft-lb	$1.35582 \times 10^7$	1.35582	192	1	12	16	$1.38255 \times 10^4$
in-lb	$1.12985 \times 10^5$	$1.12985 \times 10^{-1}$	16	$8.33333 \times 10^{-2}$	1	1.33333	$1.15212 \times 10^3$
oz-ft	$8.47388 \times 10^3$	$8.47388 \times 10^{-2}$	12	$6.250 \times 10^{-2}$	$7.50 \times 10^{-1}$	1	$8.64090 \times 10^2$
g-cm	$9.80665 \times 10^3$	$9.80665 \times 10^{-3}$	$1.38874 \times 10^{-2}$	$7.23300 \times 10^{-3}$	$8.67961 \times 10^{-4}$	$1.15728 \times 10^{-3}$	1

\*To find required units, multiply by the listed factors.

Equivalents: 1 pound (lb) = 453.5924 grams (g), 1 g = 980.665 dynes, 1 newton (new) = 100,000 dynes, 1 slug = 32.174 lb, 1 radian (rad) = 57.29578 degrees (deg).

These tables are from "A Handbook on Floated Integrating Gyros" ('58), Reeves Instrument Corp., Roosevelt Field, Garden City, N.Y. They use values from Industrial Research Service Conversion Factors and tables by Zimmerman and Lavine.



# 2

**great new  
environmental  
CANNON PLUGS**



## 1. The DPSM

**World's first environmental magnesium connector**

Sealed for high altitude and pressure applications... exceptionally light!

First completely environmental rack-panel connector

First rack-panel connector that can be used as cable connector

Four different sizes • Many insert arrangements • Polarized—4 alternate positions • Floating mounts • Moisture proof

Available with—Hermetic sealing • Co-axial contacts • Thermocouple contacts • Crimped contacts • Air lines

Can be back-mounted—permitting bench fabrication of harness assembly.

Write today for catalog DPSM-1

## 2. CT-E

**Designed for commercial jet airliners**

Shorter—lighter

No moisture trap • Moisture proof • Easy to assemble • Vibration proof

Series CT-E Connectors meet strict space and weight requirements... are immediately available in all MS insert patterns. Meet MIL-C-5015.

Write today for catalog MS-E-3

The excellent performance of each of these new plugs has been amply proved in actual use. You can depend on them for the optimum efficiency and reliability characteristic of all plugs in the complete Cannon line.

Please refer to Dept. 115



**CANNON PLUGS**

**CANNON ELECTRIC COMPANY**

3208 Humboldt St., Los Angeles 31, Calif.

Where Reliability for Your Product is Our Constant Goal.

Factories in Los Angeles; Salem, Mass.; Toronto; London; Melbourne; Paris; Tokyo. Representatives and distributors in all principal cities. Please see your Telephone Yellow Book.

## SPACE COMMUNICATIONS

lar absorption and of re atmospheric models. Its ults are presented here i form of simple graphs. graphs should enable th signer of ground-space space-ground communica equipment to make a reliable estimate of tota mospheric attenuation at v lengths of 0.87, 1.85, and centimeters.

At centimeter wavelen only the diatomic oxygen ecule and the water mol cause significant molecu sorption. There is also att tion because of scattering absorption by dust par and water droplets, but has been neglected here "Satellite Communications 38").

The attenuation per length caused by mole absorption at any point i atmosphere can be expr as a function of tempera pressure, humidity, and v length. If we adopt a spher ly stratified model atmo the total attenuation along transmission path can the found by integration.

Figure 1 shows the theoretical one-way attenu through the entire atmo as a function of altitude for three wavelengths. based on the NACA Stan Atmosphere, which has a stant relative humidity of per cent throughout the tr sphere, a surface pressur 1013 millibars, and a sm temperature of 15 deg C. model is the approxi mean of conditions over U. S. at a latitude of 40 de

For wavelengths betw 1.85 and four centimeters attenuation values will lie between the corresponding ct of Figure 1. The situatio different for wavelengths tween 0.87 and 1.85 cm. this region contains the 1 cm line of water vapor absorption.

If surface temperature relative humidity depart



COMBINED 8.7-mm radio sex-  
telescope.

ciably from the values of  
NACA Standard Atmos-  
phere, the attenuation value  
in Figure 1 must be mul-  
tiplied by a correction factor  
in Figure 2. (The tempera-  
ture correction assumes a  
smooth transition from the  
NACA Standard Atmosphere  
to the USAF Standard Hot  
and Cold Atmospheres.)

The calculations on which  
these graphs are based allowed  
for the curvature of the earth.  
However, some deviations  
must be expected because of  
non-standard lapse rates and  
horizontal gradients in the  
meteorological parameters. It  
has been found, though, that  
variations from the theoretical  
values are not large. The theo-  
retical curves normally are  
adequate for system design.

These graphs were prepared  
by the SPACE/AERONAUTICS  
Division, R. Marner, Walter R.  
Marner, and John M. Holt, Radio  
Astronomy Group, Collins  
Radio Co., Cedar Rapids,  
Iowa.

References—D. O. McCoy, "An All-  
Weather Radio Sextant," *Navigation*,  
109 (Dec. '55). G. R. Marner, "Radio-  
metric Measurement of 8.7-MM Atmos-  
pheric Attenuation," *Collins Engrg. Re-  
port* 479 ('56). G. R. Marner, "New  
Determinations of Atmospheric Micro-  
wave Absorption by Radio-Astronomical  
Means," *URSI-IRE Joint Meeting*, Apr.  
'56. For refraction and emission measure-  
ments see G. R. Marner & R. M. Rin-  
n, "Atmospheric Refraction of 8.7-  
mm Radiation," *IRE Convention Record*,  
Apr. '56, and G. R. Marner, "Atmos-  
pheric Radiation Received by Directional  
Antennas," *URSI-IRE Meeting*, Apr.



**AT CONVAIR.** This Model CF 25-50 Bath Radial Draw Former has produced hundreds of titanium and other critical parts for the F 102A and other programs at Convair.



**AT DOUGLAS.** Anti-icers, retainer seals, canopy rails, and many other parts for RB 66C, B 47 are Radial Draw Formed. DOUGLAS-TULSA STAFF PHOTO.



**AT MARTIN.** This Model CF 12 1/2-25 Bath Radial Draw Former forms titanium, stainless and aluminum parts for many of the Martin airplane and missile programs.



**32370 AURORA ROAD • SOLON, OHIO**  
(LOCATED IN THE GREATER CLEVELAND AREA)  
Manufacturers of Radial Draw Formers • Dies • Tools  
Press Brakes • Tangent Bending Sequence Presses • Press  
Type Brakes • Special Machines

# AIR PROGRESS THAT

# FIRES

# THE IMAGINATION...

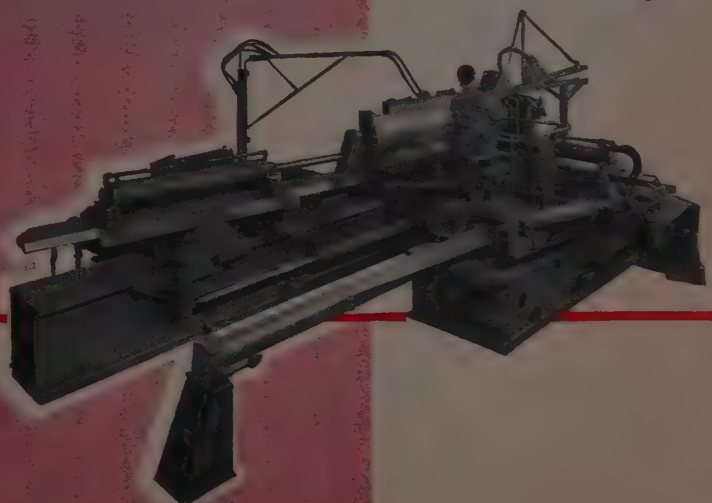
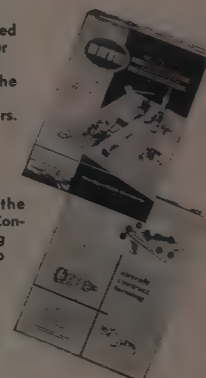
... and BATH  
radial draw  
formers are  
playing an  
important part

Great credit is due the aircraft, jet and missile industries for their fantastic progress in the last few years. The Aircraft Industry has taken us through the sonic barrier into the thermal thicket... truly, progress that fires the imagination. The titaniums, the inconels and other tough metals needed for this air progress yield best to forming by the BATH combined stretch and compression methods of Radial Draw Forming. One-piece construction in parts involving compound contours or changes in cross section throughout the contour have become possible with consequently greater strength and reduced weight.

The Cyril Bath Company is proud of the part they are playing in America's most progressive industry.

We will be pleased to send you our NEW Catalog describing the BATH Radial Draw Formers.

A Catalog describing the facilities of the Contract Forming Division is also yours for the asking.





# NEED PROOF?

ELECTRONICS OUTLOOK . . .

Continued from page 23

## These Developments . . .

. . . could radically change the space/aero electronic market

- New types of directional acceleration sensors (e.g. gyros and/or accelerometers depending on electron or nuclear phenomena)
- Successful anti-missile techniques
- Infrared vidicon
- Space communications faster than the speed of light
- Successful manned space flight
- Detection device not confined to line of sight

der's technical staff and management.

Judging by the success we're having with anti-aircraft birds such as Bomarc and Nike, our last manned interceptor might very well prove to be North American's F-108 long range Mach 3 fighter, now in early development. Many industry skeptics are even predicting that this plane may never reach production.

The global Mach 3 B-70 also in early development at NAA, in turn might be one of the last bombers. Both F-108 and B-70 will contain more electronics than any previous production aircraft (other than special early warning and electronic recon types).

An educated guess is that each F-108, with a price tag of \$2 million, will carry 25 per cent of its value in electronics. (Besides the normal CNI and FCS complement of an all-weather interceptor, the F-108 will carry HF communication, a self-contained long range navigation system, position keeping and rendezvous equipment, and an infrared fire control supplement.)

The value of the B-70 electronics system is estimated at 40 per cent of the total \$1 million unit cost. This includes the electronics in the bomber's defensive counter-measure system, which in turn includes decoy missiles.

## CRONAFLEX IS DURABLE

Same "second original" makes hundreds of exact copies.

## CRONAFLEX HAS EXCELLENT DRAFTING SURFACE

Matted on both sides, accepts pencil and ink, erases easily.

## CRONAFLEX PRINTS CLEAN

Eliminates kinks, smudges, creases from original drawing.



Better Things for Better Living

. . . through Chemistry

All Du Pont CRONAFLEX\* engineering reproduction films are dimensionally stable, resisting size changes caused by processing and temperature-humidity variations. Also, because of the clarity of its Cronar\*\* base, CRONAFLEX intermediates provide faster print-through speeds on direct reproduction equipment. Working drawings are produced faster, saving time and expense. CRONAFLEX films are available in four types: 1. Direct Positive Film, 2. Contact Film, 3. Projection Film, 4. Unsensitized CRONAFLEX. Ask your Du Pont technical representative for more information on this line or write:

E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

\*Du Pont's trademark

\*\*Du Pont's registered trademark for its polyester photographic film base.



## Electronics' Share of Missile Dollars

Share of Cost per Missile (per cent)

airborne equipment	12-60
ground equipment	40-88
guidance & control	
Non-Inertially guided missile	10-70
Inertially guided missile	20-50
Electronic ground support equipment	
Air-to-air missile	10
Air-to-surface missile	15
Shipboard-to-air missile	15
Tactical surface-to-surface missile	20
Ground-to-air missile	25
Strategic surface-to-surface missile	30

In a nutshell, the transition from aircraft to missiles means more dollars for electronics. It means a new distribution of the money, since many aircraft electronic suppliers haven't yet penetrated the missile electronics market.

An aircraft carries more electronics than a missile built for the same mission. But there will be more missiles, and there will be more electronics on the ground in a missile system (for ground support and, in most non-inertial systems, for ground parts of the guidance.) The military should spend out 2½ times more for missile electronics than for aircraft electronics in the next decade. Based on estimated R&D expenditures. This assumes electronics segments of 33 per cent for aircraft and 33 per cent for missiles does not cover R&D. \$0.4 billion should be spent for missile electronics alone in fiscal 1958-68.

One of the most drastic changes in missile electronics will come in guidance. Industry estimates based on known projects predict that,

more on next page

Note the performance data on this new



Actual size

# CRYOGENIC CHECK VALVE

by LEONARD

Let us review your special requirements



Wallace O. Leonard, Inc.  
373 South Fair Oaks Avenue  
Pasadena, California

Telephone SYcamore 2-7131  
TWX - Pasa Cal 7321

Zero leakage at 0 to 35 G's from 20 to 2000 CPS

Cracking pressures to a low of 0.25 PSI

Operating pressures above 4000 PSI

Flight certified for liquid or gaseous helium, oxygen, and nitrogen

Now available for line sizes ¼" to 1.0"

9-113

Circle No. 159 on Reader Service Card in Product Review Section

## specialists in HEATING ELEMENTS

This quantity production element heats a resistoflex couple which is a flexible line 1¼" in dia., made of braided steel wire with hex fittings at each end. Line must be heated because it transmits liquid at very low temperature. Unit embodies snap-action thermostat sensing tubing temperature to hold 70 to 100°F.

If you have a special heating problem let us solve it for you. We are specialists in light-weight, tough, flexible elements of any shape or size. Units may be designed to operate under high pneumatic pressure. Insulation may be Silicone Rubber or Neoprene. Elements may be immersible or resistant to corrosion. All units meet USAF specifications.

send for free illustrated booklet

### Electro-Flex Heat, Inc.

83 WOODBINE ST., HARTFORD, CONN. (CHapel 7-2401)

"FIRST" and "STANDARD" ELEMENTS

## ELECTRO-FLEX

solves another difficult heating problem.

THIS TIME FOR...



Rocketdyne Division of North American Aviation, Inc.  
Canoga Park, California  
Material: Silicone rubber sponge, flexible enough to bend with the tubing.  
Rating: 200 watts at 115 V. (1250 V. breakdown)  
Resistance Tolerance: ±5%

Send for FREE SAMPLE PACKET of the three new MUELLER "70 SERIES" ALLIGATOR CLIPS. Low-cost, streamlined clips

with **SNAP!**

THIS IS AN ACTUAL HIGH SPEED SEQUENCE PHOTOGRAPH OF A NEW "70 SERIES" ALLIGATOR CLIP

which is taking 1/2500th second to snap shut upon a wafer. Talk about acceleration!—the upper jaw hits 60 MPH in three-eighths of an inch. The upper jaw and flying wafer fragments have been caught in many images along their paths of movement.

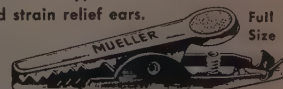
Photographed by means of a special process, it graphically illustrates the "snap" in Mueller's traditionally snappy springs. These springs provide a mean, corrosion-cutting bite for perfect test connections.

### THE NEW "70 SERIES" ALLIGATORS FEATURE:

Simple, direct, streamlined design, and lower cost than the famous "60 Series".

Faster, easier connection, whether screw type or soldered. A new patented hinge, and cord strain relief ears.

WRITE FACTORY TODAY FOR FREE SAMPLE PACKET SHOWN ABOVE



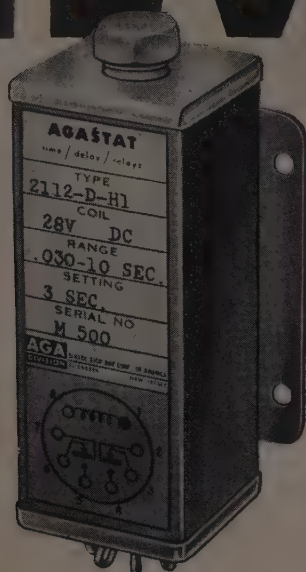
**Mueller Electric Co.**  
15/85 East 31st Street • Cleveland 14, Ohio

Circle No. 161 on Reader-Service Card

Circle No. 160 on Reader-Service Card



# NEW



## MINIATURE AGASTAT®

### time delay relay

*for . . . missile, aircraft and  
electronic applications*

**INSTANTANEOUS RECYCLING** . . . reset time—less than .020 seconds

**UNAFFECTED BY VOLTAGE VARIATIONS** . . . time delay remains constant from 18 to 30 volts DC

**ADJUSTABLE** . . . time delays from .030 to 120 seconds

**CHOICE OF OPERATION** . . . for either energizing or de-energizing

**SMALL** . . . height—4½" . . . width—1-13/16" . . . depth—1½"

**LIGHT** . . . maximum weight—15 ounces

**MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A**

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit, built to withstand the rugged environmental conditions of missile and aircraft applications.

For specific information on the new AGASTAT relay for your application, write to Dept. A29-119.



**ELASTIC STOP NUT CORPORATION OF AMERICA**

1027 Newark Avenue, Elizabeth, New Jersey

Pioneers in pneumatic timing

Circle No. 162 on Reader Service Card in Product Review Section

## ELECTRONICS OUTLOOK . . .

### DOD Expenditures Largely Made for Electronics (billion)

Fiscal Year	1957	1958	1959 <sup>1</sup>	1960 <sup>1</sup>	1961 <sup>1</sup>	1962 <sup>1</sup>	1963 <sup>1</sup>	1964 <sup>1</sup>
Major Procurement & Production <sup>2</sup>								
Aircraft	7.9	8.4	7.2	5.8	5.2	4.5	4.5	
Guided missiles	2.1	2.7	3.4	4.6	5.7	6.2	6.5	6
Electronics & Communications <sup>3</sup>	0.9	0.9	0.7	1.2	1.6	1.9	1.9	2
R&D <sup>4</sup>	1.7	1.7	2.4	2.5	2.7	3.2	3.3	3
Total	12.6	13.7	13.7	14.1	15.2	15.8	16.2	16
Total for electronics <sup>1</sup>	3.506	4.0	4.5	4.5	4.5	4.5	4.5	4.5

(1) Industry estimates. (2) DOD Major Procurement & Production categories covering small electronic expenditures and not shown here are: Ships & Harbor, Ammunition (fuzing systems and components), Military Public Works, and Reserve Components. (3) category covers mainly "Signal-Corps-type" ground-to-ground systems. (4) Actual amount on R&D by DOD come to 150-200 per cent of expenditures officially labeled as R&D here. The extra funds are taken from the Major Procurement & Production allocation.

by 1962, the total spent for guidance will rise from the present \$390 million per year to \$930 million. The amount spent on inertial guidance (IG) is predicted to increase by 380 per cent—from \$150 million to \$570 million in 1962. Non-inertial systems funds will also rise, but at a slower rate—from \$240 million to \$360 million in '62.

The reasons for the shift to IG are:

- IG's invulnerability to countermeasures;
- several inertially guided missiles can be launched at once;
- logistics problems are reduced, since IG is self-contained;
- Advances in the state of the IG art—Redstone is said to have a circular error probability (CEP) of 500 yd and Regulus II one of less than 600 yd; gyros, it is believed, are being produced with drift rates of less than 0.003 deg/hr and precision pendulous integrating accelerometers with ranges from  $10^{-6}$  to  $10^6$  G; transistorization has provided drastic size and weight reductions—AC reportedly cut its basic IG system from over 1000 to well under 500 lb

mainly through transistorization.

The IG dollar is split three ways: 35 per cent for electronic mechanical gear (gyros, accelerometers, servos, etc.), 30 per cent for electronics (amplifiers, computers, etc.), and the remainder for testing. (On non-inertial systems, this split works out to 10, 65, and 25 per cent.)

### AC Spark Plug has half of all IG business

The only IG systems known to have been produced are those for Jupiter, Mace, Redstone, Regulus II, and Thor. All except the Redstone's systems, three are made by AC Spark Plug, which is now doing about half of all IG business. However, once the IG systems for Atlas, Hound Dog, Minuteman, Pershing, Polaris, Sergeant, Titan, and Wagtail start to come off the line (reportedly between now and 1962), the lead should go to Arma and Autonetics (assuming Titan is not phased out as persistent industry rumor claim).

Arma and Autonetics have top developmental reputations in the IG field, but neither has



e a production system as  
Production capability will  
an especially strong factor  
etermining who is to get  
re IG business. So far, AC  
rk Plug and Ford Instru-  
nts are the only proven  
ducers.

riefly, here is how the IG  
pected to be used:

Surface to surface—Some  
of the ballistic missiles  
own to use IG should be  
t this year and almost three  
es, as many in 1962. Long  
ge cruise types such as  
ce, Regulus II, and Snark,  
use aided IG systems.  
duction will approach some  
of these in 1959, but their  
beyond 1960-1961 is in  
bt.

market seen in Army's  
rt range birds

Army short range missiles  
ht prove to be one of the  
t profitable markets for IG.  
t 10,000 of these birds  
being turned out annually.  
ong them, however, only  
eant has IG and this bird  
being produced in limited  
umbers.

Air-to-surface — About  
of these birds (Corvus,  
en Quail, Hound Dog,  
tail) are using IG. The  
eased use of air-to-surface  
s by long range bombers  
for offense and decoy  
rvus and Quail) should  
n healthy production rates  
the next 3-6 years.

Air-to-air and surface-to-  
IG is not being used here  
studies are underway to  
k its feasibility. The idea  
use a Mach 6-9 bird; the  
nise, that the attacking  
ile would be too fast for  
target to maneuver out of  
lethal area in time. Iner-  
systems probably would  
ide inexpensive guidance  
such missiles.

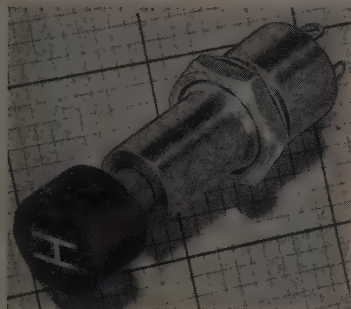
rn back to beginning of  
xt article on page 24

ry 1959

# HETHERINGTON

SWITCHES • INDICATOR LIGHTS • SPECIAL ASSEMBLIES

## ENGINEERING NEWS



### A NON-SNAP SWITCH FOR "KEYBOARDS"

Developed specifically for the key-boards of electronic computers, calculators, and other business machines, the Hetherington B5023 gives the smooth, yet precise action necessary for fast manipulation. Operating pressure is a scant 1/2 pound — just enough to retain the familiar keyboard "feel."

The versatile 2-circuit, momentary-contact circuitry of the B5023 can also be used as SPST or SPDT. Recent tests have shown a life of better than 1.7 million operations at 5 amps., 30 volts dc. This is far greater than the conservative rating you'll find in Bulletin S-6 if you write for it.

Circle No. 100 on Reader-Service Card

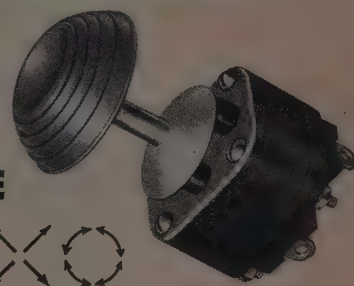


### New SWITCHLITES™ for "Human-Engineered" Panels

Wherever switches and indicator lights are used on the same panel, Hetherington Switchlites can play a major part in improving panel legibility and operating convenience. For the pushbuttons of these compact snap-action switches contain their own built-in indicator lights for easy, direct association of switch and light functions. Moreover, they save greatly on panel space, wiring, installation and removal time.

So many different Hetherington Switchlites are now available that

### THUMB-OPERATED "TOGGLE" CONTROLS 4 SEPARATE SWITCHES



A familiar sight to helicopter pilots is this versatile Hetherington Type F441 Four-Way Switch. Here it is housed, along with other Hetherington Switches, in a hand-grip which fastens to the flight control stick. Moving the Switch's thumb-type knob up or down, right or left, operates control motors for hoists or lateral trim.

Housed in the 1-1/4" by 7/8" phenolic case of the F441 are 4 separate momentary-contact switches arranged 90 degrees apart around the base of a thumb-controlled toggle lever. Normally, all switches are "open" and the toggle is centered.

Usually the switch is mounted so that the lever projects through

Circle No. 101 on Reader-Service Card

a cloverleaf gate that restricts operation to one switch at a time. Without the gate however, any two adjacent switches may be closed simultaneously. The toggle may also be held outward, and moved in an arc to actuate all 4 switches in succession.

Admittedly, the F441 Switch is rather specialized. However, it offers industrial users interesting opportunities to simplify equipment design and operation — by saving space, by "foolproofing" critical circuits, or by making operations easier to understand.

No bulletin is available on this switch as yet, but ratings and a dimension drawing will be sent on request. Ask about the F441.

### Now! AT LEADING PARTS DISTRIBUTORS

Need Hetherington products for prototypes, breadboard models, special projects, or small production runs? Most popular Hetherington items are available at local electronic parts distributors everywhere.

For the name of your nearest parts distributor and bulletins of the Hetherington Switches, Indicator lights, and Switchlites he carries, write directly to: **DISTRIBUTOR'S DIVISION, HETHERINGTON INC., 26 Rittenhouse Place, Ardmore, Pa.**

only a few of their many features can be mentioned here:

Switch Circuits: SPST, SPDT, DPST, DPDT, or 2-circuit. Up to 15 amps @ 28 v. dc.

Snap-Action: Push, momentary; Pull, momentary; Push-Pull, maintained; Push-Push, maintained; Push-Pull, maintained with auxiliary momentary on "push."

Lamp Circuit: Case ground or separate gnd. terminal. "Hot" lead to separate terminal, thru main sw. contacts, or thru separate built-in sw. circuit. 6, 14, 18, 28 volt AN3140-type lamps.

Pushbutton Lenses: 10 styles, each in 10 transparent or translucent colors. Lettering may be engraved on all.

New Bulletin S-7 gives complete details on all Hetherington Switchlites.

Circle No. 102 on Reader-Service Card

**HETHERINGTON INC.** DELMAR DRIVE, FOLCROFT, PA. • 139 Illinois St., El Segundo, Calif.

better switch engineering for a pushbutton world

A Controls Company of America Subsidiary



CURTISS-WRIGHT

REPUBLIC AVIATION

FAIRCHILD

HUGHES



Pratt &amp; Whitney Aircraft

MARTIN CONVAIR

BOEING

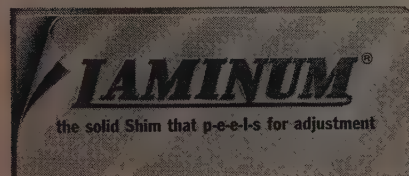
CHANCE VUGHT

LOCKHEED



Sikorsky technician peels a lamination from a 5" diameter Shim designed for tail take-off assembly.

At Sikorsky, as at most other leading manufacturers of aircraft and missiles, laminated Shims of LAMINUM insure assembly of components with no margin for error. Shims of LAMINUM, which peel for a thousandth fit right at the job, always deliver a 3-fold advantage: they save time, improve quality and cut costs.



Laminum looks, acts like solid metal—yet quickly p-e-e-l-s to precision fit right at the job. In Brass, Mild Steel, Type 302 Stainless with .003" or .002" laminations. In Aluminum with .003" laminations or **NEW** with .002" laminations. Custom-made, Laminum Shims eliminate extra operations: no machining, no grinding, no stacking, no miking. And no grit between layers—ever!

Circle No. 164 on Reader Service Card in Product Review Section

**FREE!** Actual sample of LAMINUM—also illustrated Engineering Data File. Write for your copy today.



EAST COAST

Home Office and Plant  
5301 Union Street  
Glenbrook, Conn.

WEST COAST

Sales Office  
600 Sixteenth St.  
Oakland 12, Calif.

## INERTIAL GUIDANCE

Continued from page 24

three single-degree-of-freedom gyros for a complete directional reference system, whereas just a pair of two-degree-of-freedom units will do the job.

Current gyro designs differ in a number of details, among them:

- degree of damping (in single - degree - of - freedom types),
- nature of spin bearings,
- suspension used to supplement flotation (e.g., jewel pivot, magnetic, flexural, hydrodynamic),
- nature of angle pickoff,
- nature and accuracy of torque generator (both ac and dc types are used with accuracies varying from 0.01 to about one per cent).

Successful inertial gyros have been designed about all of these variations, but none of them enjoys a clear-cut lead. Most applications, though, use the highly damped, single-degree-of-freedom type. This has been found suitable for all but the most severe guidance applications under study.

## Flotation and flexural suspension common

With few exceptions, IG accelerometers are basically pendulums kept centered by some type of torque feedback. Suspension methods include all those we have noted for gyros, with flotation and flexural types the most common ones. Devices using flexural suspension tend to be simpler and more compact, but are still subject to null shifts caused by imperfect coincidence between the zero torque angle of the suspension and the null angle of the pickoff.

Several conventional accelerometer designs use moving-coil, permanent magnet field devices for creating the force or torque feedback. The best examples of this approach give accuracies on the order of 0.01 per cent.

Still other pendulous accelerometers make use of the

You can't see the DORNE & MARGOLIN antenna but the world knows it's there!

Dorne & Margolin has designed more antennas for more different missiles and aircraft than any other company in the nation.

WRITE FOR CATALOG  
**DORNE & MARGOLIN, INC.**  
29 New York Ave., Westbury, N.Y.  
West: 1434 Westwood Blvd.  
Los Angeles 24, Cal.

Circle No. 165 on Reader-Service Card  
SPACE/AERONAUTICS





WEIGHT airborne inertial form.

produced when you change the angular momentum of a wheel to balance the torque applied by acceleration on the bob. Because the change of a body's angular momentum is exactly proportional to the applied torque, this principle yields extremely accurate accelerometers. Designs of this general type take two basic forms: the pendulous gyro accelerometer and the kinetic doubly integrating accelerometer.

The pendulous-gyro design balances the gyro precession against the pendulum torque. The output of this device is a shaft angle proportional to the first time integral of acceleration. In the kinetic, doubly-integrating accelerometer, the acceleration of a flywheel is balanced against the pendulum torque. Its output is a shaft angle proportional to the second time integral of acceleration.

When you're dealing with high velocities, the pendulous gyro type works best. At low velocities, the kinetic, doubly-integrating device is more satisfactory. Because of the inherent accuracy of the torque-balance principle, both types can be made highly accurate (substantially better than 0.01 per cent). The error comes from uncer-

more on next page

# IMPROVED CHARACTERISTICS

...OF  
SPECIAL  
INTEREST  
TO AVIATION  
ENGINEERS

## DELCO HIGH POWER TRANSISTORS



UNEXCELLED FOR LIGHT WEIGHT, SMALL SIZE, EFFICIENCY, RELIABILITY, SWITCHING

TYPICAL CHARACTERISTICS AT 25°C.

	2N1100	2N1099	2N174A	2N174	2N173	2N278	2N277	2N443	2N442	2N441
Maximum Collector Current	15	15	15	15	15	15	15	15	15	15 amps
Maximum Collector Voltage (Emitter Open)	100	80	80	80	60	50	40	60	50	40 volts
Saturation Resistance	.02	.02	.02	.02	.03	.03	.03	.03	.03	.03 ohms
Thermal Gradient (Max.) (Junction to Mounting Base)	.8	.8	.8	.8	.8	1.0	1.0	1.0	1.0	1.0 °C/watt
Base Current $I_B$ ( $V_{EC}=2$ volts, $I_C=5$ amps)	135	100	135	135	100	100	100	150	150	150 ma
Collector to Emitter Voltage (Min.) Shorted Base ( $I_C=.3$ amps)	80	70	70	70	50	45	40	50	45	40 volts
Collector to Emitter Voltage Open Base ( $I_C=.3$ amps)	70	60	60	60	50	45	40	55	45	40 volts

\*Designed to meet MIL-T-19500/13A (Jan) 8 January 1958 †Formerly DT100 ‡Formerly DT80

Check your requirements against the new, improved characteristics of Delco High Power transistors. You will find improved collector-to-emitter voltage... higher maximum current ratings—15 amperes, and extremely low saturation resistance. Also, note the new solid pin terminal design.

And of special importance to you is the fact that diode voltage ratings are at the maximum rated temperature (95°C.) and voltage.

Write today for engineering data on the new, improved characteristics of all Delco High Power transistors.

## DELCO RADIO

Division of General Motors • Kokomo, Indiana

BRANCH OFFICES

Newark, New Jersey  
1180 Raymond Boulevard  
Tel: Mitchell 2-6165

Santa Monica, California  
726 Santa Monica Boulevard  
Tel: Exbrook 3-1465

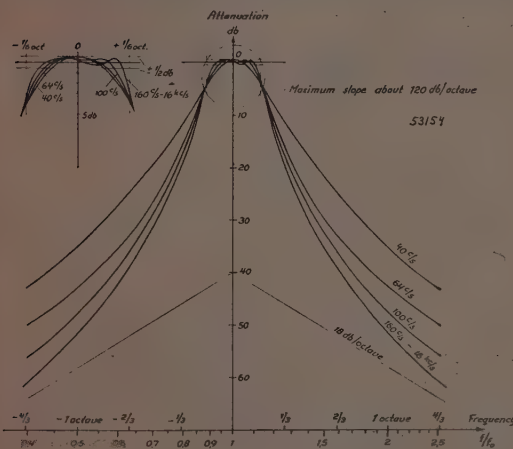
Circle No. 97 on Reader Service Card in Product Review Section



# New: ...and improved model 2110 AUDIO FREQUENCY SPECTROMETER



Typical Applications include:  
Recording Noise Spectrograms  
Measurement of Reverberation Time  
Measurement of Vibration Insulation  
Distortion Measurements







Integrating accelerometers (left) and advanced floated (right).

are currently being licked now by the increasing use of power transistors. In fact, transistorized circuitry is becoming fairly commonplace in inertial guidance servos.

We have already noted that every dynamic restraint is needed in pendulous accelerometers to keep vibration errors down. To keep delays to a minimum, many of these designs use very high carrier frequencies. In certain cases, the mechanical resonances become a limiting factor for usable frequencies.

Early IG systems used analog computers almost exclusively, partly because the available signals were basically analog and partly because the electronic sensors themselves limited system accuracy. Also, early digital machines were too bulky for most airborne guidance applications.

Recent refinements in sensor accuracy have focused attention on the accuracy limits of analog machines. Also, with transistorization the digital computer has become a very compact, lightweight device. For these reasons, it is coming into its own in IG.

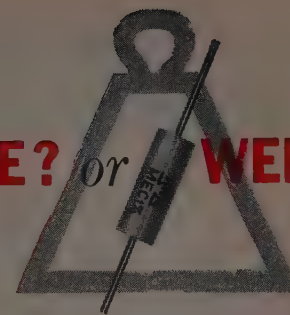
Digital computer design for inertial uses is following two main approaches: general-purpose types and the digital differential analyzer (DDA). IG designers are still not in agreement as to their merits, and probably too early to tag

more on next page

concerned about



SPACE? or WEIGHT?



## USE NEW IRC MOLDED METAL FILM PRECISION RESISTORS

If you need the precision of a wire wound resistor, but in a space-saving, weight-saving size, IRC's new Type ME Metal Film Precision Resistors are for you.

Not only do they save weight and space but they are equal or superior to wire wound resistors in many respects as noted at right:

1. Higher environmental performance
2. Higher statistical performance on environmental tests
3. Higher ambient, extended life, extended moisture and temperature cycling
4. Better RF characteristics
5. Comparable or lower in cost
6. Resistance values are stable—just as stable for a 1% resistor as for a 0.10% resistor—just as stable for low T.C.'s as high T.C.'s.

**TEMPERATURE COEFFICIENT**—In order to meet the variety of T.C. requirements, precision metal films are offered in eight classifications. You may order T.C.'s as close as those for precision wire wounds... or, where it is not critical, T.C.'s up to  $\pm 100$  PPM are available. Classifications are listed below:

Classification	PPM	Temperature span
T-1	$\pm 100$	$-55^{\circ}\text{C} + 165^{\circ}\text{C}$
T-2	$\pm 50$	$-55^{\circ}\text{C} + 165^{\circ}\text{C}$
T-3*	$-0 + 100$	$-55^{\circ}\text{C} + 165^{\circ}\text{C}$
T-4*	$+0 - 100$	$-55^{\circ}\text{C} + 165^{\circ}\text{C}$
T-5	$\pm 25$	$+25^{\circ}\text{C} + 105^{\circ}\text{C}$
T-6*	$+50 - 0$	$-55^{\circ}\text{C} + 165^{\circ}\text{C}$
T-7*	$-50 + 0$	$-55^{\circ}\text{C} + 165^{\circ}\text{C}$
T-8*	$\pm 25$	$-55^{\circ}\text{C} + 165^{\circ}\text{C}$

\*Special types.

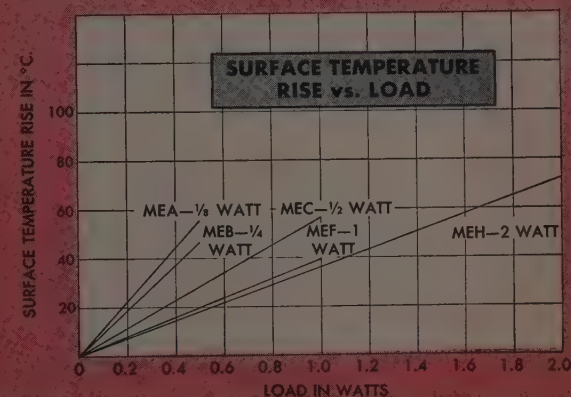
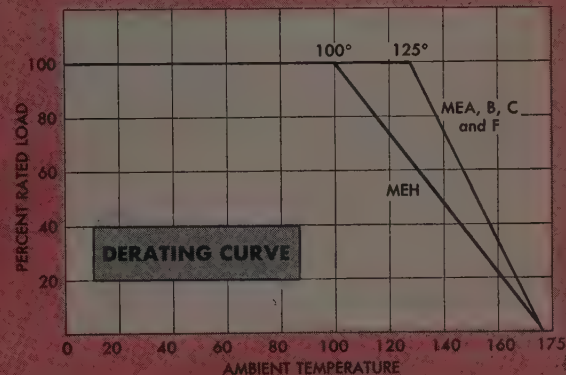
**OTHER CONSTRUCTION ADVANTAGES**—The new IRC Molded Metal Film Resistors eliminate two other bugaboos of wire wound resistors.

1. No cold joint problem. There is no unsolderable resistance wire in the metal film resistor to be soldered to the terminals. 2. No failure due to excess winding stresses because there are no windings.

IRC Type	5 Wattage Ratings (125°C Ambient)	Maximum Continuous Voltage Rating	New Range Minimum** Ohms	New Range Maximum** Ohms
MEA	1/8	250 V	30	500 K
MEB	1/4	300 V	50	1 meg
MEC	1/2	350 V	50	1.5 meg
MEF	1	500 V	50	4 meg
MEH	2*	750 V	100	10 meg

\*100°C Ambient Max. below 500 K ohms.

**\*\*NEW EXTENDED RANGES**—These new ranges have lower minima and higher maxima by far than our former corresponding values.



Write for New Catalog Data Bulletin



INTERNATIONAL RESISTANCE COMPANY • Dept. 191 • 401 N. Broad St., Phila. 8, Pa. • In Canada: International Resistance Co. Ltd., Toronto, Licensee  
Circle No. 167 on Reader Service Card in Product Review Section



**Research and Development  
Engineers and Physicists  
Specializing in Servos, Circuits,  
Microwaves, Transistors, Computers**

## Make the most of your experience

Work on advanced projects such as airborne radar, analysis and development of circuits for advanced radar systems; electronic analog computers and general purpose digital computers; checkout and test equipment; bombing navigation systems; inertial guidance; analytical studies associated with new electro-mechanical systems.

Also positions for: engineering handbook writers; computer programmers; standards hardware parts designer with strong background in fasteners; research engineer to plan and execute research program involving inorganic materials in electronic equipment and to perform chemical analysis of materials; senior estimators for manufacturing cost analysis proposals.

Autonetics offers a 12-year stockpile of experience in the design, development, and quantity manufacture of flight controls, inertial navigators, armament controls, automated machine controls, computers, landing systems, radar systems, data processing equipment, and electro-mechanical servo systems—plus a complete flight test section and specialized engineering and production facilities.

**Send resume to:**

**Mr. D. A. Brunetti**  
Autonetics, 9150 E. Imperial Highway  
Downey, California

**Autonetics**

A DIVISION OF NORTH AMERICAN AVIATION, INC.  
NERVE CENTER OF THE NEW INDUSTRIAL ERA



## INERTIAL GUIDANCE

either approach as the more promising.

The trend to digital computers for IG has spurred an intensive program to produce basic sensors with direct applicability to digital systems. This would do away with the inefficient excessive use of analog-to-digital transducers.

The cost of IG equipment is tied closely to the very touchy manufacturing processes needed to get the desired accuracy. You can only get high tolerance manufacturing for a price. The complexity factor—involving such things as the quantities of diodes, transistors, etc., used in computers—is second to accuracy in pushing up the cost.

There's no absolute way to relate size and weight to accuracy. But experience shows there is a relationship—within limits, accuracy can be improved by going to bigger size. Advances over the past few years have brought radical cuts in size and weight. Whereas the earlier IG systems weighed in at thousands of pounds, current packages weigh in the hundreds and, where less accuracy is needed, break 100 lb.

In IG equipment, even a slight loss in performance brought on by wear or misadjustment makes the system worthless. In other words, reliability is closely tied to accuracy needs.

The trends in IG are not yet firmed up (save in a few cases such as the wide acceptance of digital computers and the swing to beryllium for gyro and accelerometer structures). The main reason for this is that the rapid advances in the art took place during the early years. The past few years have been more a period in which the early gains were consolidated.

Designers, faced with diminishing returns for their efforts, are avidly searching for new principles to work with. The most promising areas here include electrostatic suspension

**MARMAN**

## Engineering Notes



W. M. WILLIS

Scientific sealing, rather than the brute-force approach, is the future of the Marman Conoseal that has successfully exceeded sealing requirements for tomorrow's aircraft missiles. As opposed

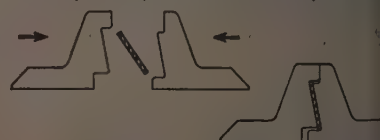
to bolted flanges which invariably yield or loosen during thermal cycling, the Marman all-metal Conoseal closely approximates the flexibility of organically sealed joints and endures repeated extremes of thermal cycle while still maintaining a perfect seal.

In the low-temperature range ( $-320^{\circ}\text{F}.$ ) the joint has been successfully tested with liquid oxygen and liquid nitrogen using metal-to-metal transitions of aluminum flanges to stainless steel flanges. Recent experiments conducted by leading airframe manufacturers have illustrated why the safety features of the Conoseal are a necessity. Impact sensitivity tests conducted by this company reveal that certain materials, such as synthetic elastomers, cellulose base papers, thermo-plastics and thermo-setting resins, including phenolics and silicones would explode when saturated with liquid oxygen and subjected to shock impact. The chemical inertness of the metal Conoseal precludes any possibility of explosion during use of liquid oxygen, and in effect, is an anti-explosion joint.

Rigorous laboratory tests at Marman Division Aeroquip Corporation, have proven the high temperature and pressure-sealing capabilities of the Conoseal exceed the capabilities of pipe or tubing. Prototype tests now being conducted by various customers have demonstrated successful applications in liquid metal such as liquid sodium at  $1600^{\circ}\text{F}.$  In outstanding tests of other applications, a 14-in. Conoseal used in a thrust vector control nozzle on a solid propellant rocket successfully withstood a nozzle temperature of  $4600^{\circ}\text{F}.$  for 90 seconds duration.

The Engineering Department at Marman has not overlooked the requirements of plant engineers and test equipment designers in the development of a 6400-series, heavy-duty pipe Conoseal. This rugged industrial joint retains all the maintenance, assembly, and sealing abilities of the aircraft joint, but is specifically designed for industrial usage.

Complete test reports are available upon request, covering performance of the full ranges of joint types available for your aircraft, missile, and industrial requirements.



Cross-sectional drawings of the CONOSEAL joint show how the Belleville-type metal gasket is purposely compressed beyond its elastic limit to form a high pressure seal of continuous balanced radial and axial forces.

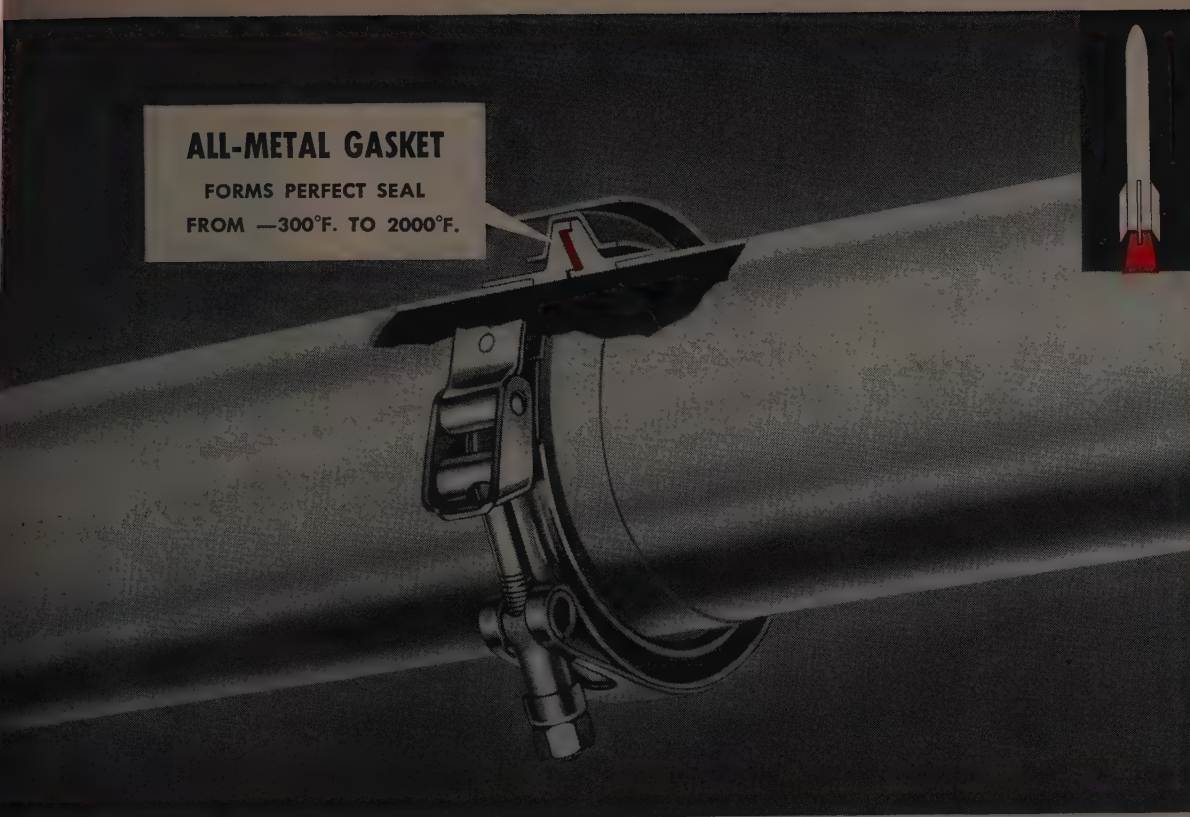
*W. M. Willis*

ENGINEERING MANAGER  
MARMAN DIVISION, AEROQUIP CORPORATION



## ALL-METAL GASKET

FORMS PERFECT SEAL  
FROM  $-300^{\circ}\text{F.}$  TO  $2000^{\circ}\text{F.}$



# 100% Metal! That's Why **MARMAN** CONOSEAL Joints Assure Unlimited Shelf Life With Perfect Seal

Marman's all-metal CONOSEAL Joint provides two basic advantages over organically sealed tube joints:

- 1—shelf life is practically unlimited
- 2—seal is maintained from  $-300^{\circ}\text{F.}$  to  $2000^{\circ}\text{F.}$

The CONOSEAL Joint utilizes a new concept of metal-to-metal sealing in which the conical metal gasket is completely encased by mating flanges. Compressed radially and axially, the gasket forms a superior seal that withstands extreme pressures and wide thermal cycling. Distortion, shock, even minor linear deflections are absorbed without loss of seal.

The compact design of the Marman CONOSEAL Joint minimizes envelope clearance needed. Single bolt fastening simplifies installation. Ideal for fluid transfer lines and structural joints, it is available in four weight/strength configurations for both air and ground installations. Mail coupon for complete new catalog.

CONOSEAL is an Aeroquip Trademark.

**MARMAN DIVISION**

**Aeroquip Corporation**

11214 EXPOSITION BLVD., LOS ANGELES, CALIFORNIA  
IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO  
Marman Products are Covered by U.S. and Foreign Patents and Other Patents Pending

Circle No. 169 on Reader Service Card in Product Review Section

Marman CONOSEAL Joints are available in four operating performance ranges. Standard sizes from 1" to 12" O.D. tube size. Special sizes available.

Joint Type	Temp. Range ( $^{\circ}\text{F.}$ )	Max. Pressure (5" size 70" F.)
Lightweight	$-300$ to $+1250$	1200 psig
Light Duty	$-300$ to $+750$	1500 psig
Medium Duty	$-300$ to $+1250$	3300 psig
Heavy Duty	$-300$ to $+2000$	6000 psig

Aircraft Sales Dept., Marman Division, Aeroquip Corporation  
11214 Exposition Blvd., Los Angeles 64, California

Please send me full information on Marman CONOSEAL Joints. I am concerned with temperatures from \_\_\_\_\_ $^{\circ}$  to \_\_\_\_\_ $^{\circ}$ , pressures from \_\_\_\_\_ psi. to \_\_\_\_\_ psi. type of fluid \_\_\_\_\_ diameter

Name \_\_\_\_\_  
Title \_\_\_\_\_  
Company \_\_\_\_\_  
Address \_\_\_\_\_  
City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_ SA-7

## INERTIAL GUIDANCE

for gyros and accelerometers, gas-lubricated spin bearings, nuclear spin gyros, and applied cryogenics.

For relatively long airborne missions, inertial systems still don't have enough long-term accuracy to go it alone, though advances in gyro mechanics have cut significantly into drift error. Until this problem is licked, hybrid systems using other sensors to supplement the inertial ones will be needed for some time to come. Among the more common combinations are the stellar-inertial and Doppler-inertial systems.

Stellar-inertial systems use an automatic star tracker to determine drift and provide correcting signals. In some instances, the tracker is used only for correcting heading direction, so that it needs a line of sight to only one celestial body. This type can take a fix on the sun during the day and on stars at night.

Doppler-inertial systems may use the radar data either for damping purposes only or as the prime source of velocity information. In the latter case, the inertial system is used basically to get the high frequency data on vehicle motion, allowing heavy filtering of the Doppler signal.

Space travel poses some special problems for IG, which are under close study. There's little doubt that inertial systems will be used for the launch phase, but once the spacecraft is underway, you have virtually negligible accelerations (actual acceleration will always be in balance with G-effects). Thus we'll have to rely on computations based on celestial mechanics to determine paths through space. Only when we want to change course will inertial methods again apply.—End

Turn back to beginning of next article on page 25

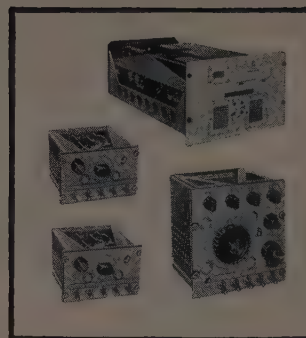


## COMMUNICATIONS

Radio Set AN/ARC-57 . . . designed and developed by *The Magnavox Company*, in conjunction with the Air Force, is an essential UHF communications system, providing the utmost in performance and reliability for the CONVAIR B-58.

It clearly demonstrates *The Magnavox Company's* ability to produce and work as a prime contractor on a complex weapons system.

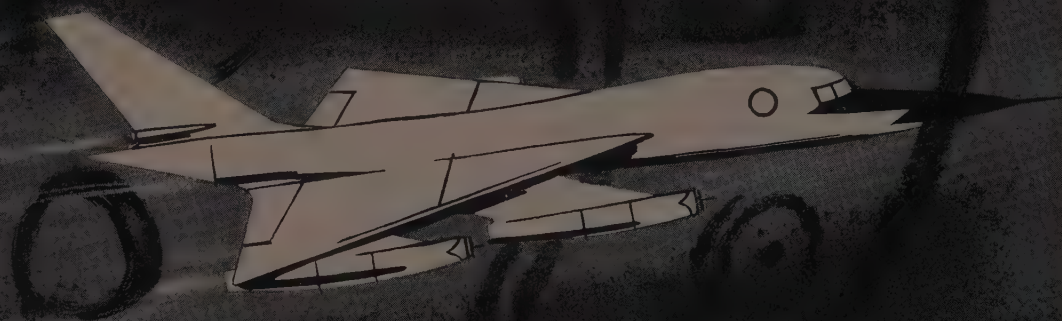
*MAGNAVOX capabilities are in The Fields Of Airborne Radar, ASW, Communications, Navigation Equipments, Fusing and Data Handling . . . your inquiries are invited.*



PRODUCTS  
THAT SPEAK FOR  
THEMSELVES

# Magnavox

MAKES THE B-58 TALK!



THE MAGNAVOX CO. • DEPT. 33 • Government and Industrial Division • FORT WAYNE, IND.  
Circle No. 170 on Reader Service Card in Product Review Section

## INFRARED

Continued from page 26



**STARFIGHTER'S IR** gunsight gives nighttime capability in conjunction with optical gunsight in fire control system.

IR engineers have recognized for some time not only that many types of military targets radiate profusely wavelengths above 3 microns but also that the background problem is less severe here than in the 1-3-micron region. The commercially available lead sulfide (PbS) detector sensitive in the latter region and is used in many of the systems under development.

One infrared scanning device with a PbS detector has reached operational status as part of the AN/ASG-14 fire control system in the Lockheed F-104. In conjunction with the optical gunsight, this installation provides nighttime capability. Similar IR scanners are slated for other line aircraft.

New search and surveillance IR systems are taking form steadily. The many different operational uses for these classes of IR equipment have led to a good deal of work with various design parameters. Where high sensitivity is important, we're studying field division by means of multiple-detector systems. Small optical and mechanical devices that scan the field of view with high efficiency are under development.

**Rapid-scan detectors for better IR recon**

For some time now we've been applying discrimination techniques against unwanted backgrounds in scanning systems.

SPACE/AERONAUTICS



IN AVIATION, E101 is widely used to reduce preliminary design and test data on aircraft, missiles and components . . . to provide accuracy checkpoints on complex problems for large-scale computing equipment. Pinboard programs reduce the data from test equipment readings; the results are directly printed.



# pinboard programming saves 95% of manual computation time!



# e101

## Burroughs

*electronic digital computer*

Users of Burroughs E101 low-cost digital computers report average time savings of 20 to 1 over desk calculators and other manual devices . . . plus superior accuracy. Savings in calculating time frees technical talent for more creative jobs . . . ensures better design . . . allows fuller employment of laboratory facilities . . . bigger work loads. Simplified pinboard programming can be mastered in a matter of hours. Problem solving capacity is further extended by optional PUNCHED PAPER TAPE INPUT/OUTPUT equipment and the NEW PUNCHED CARD INPUT unit, for direct computer processing of punched card files. For brochure, write ElectroData Division, Pasadena, California.



**Burroughs Corporation**

"NEW DIMENSIONS/in electronics and data processing systems"

Circle No. 98 on Reader Service Card in Product Review Section

variety of special forms of  
ultraviolet detectors is avail-  
commercially.

Both spectral filtering by  
interference filters and  
filtering through reticles  
image plane are being

ge-forming devices, such  
reconnaissance systems,  
benefiting from the rap-  
response characteristics of  
new 3-5-micron detec-  
Such detectors as indium  
onide, for instance, give  
more detailed picture at  
scanning speeds than  
lower detectors. New op-  
and mechanical tech-  
s for rapid scanning are  
being pushed.

tracking systems have  
ed operational status in  
applications as the Side-  
er and Falcon GAR-2A  
es, using PbS detectors.  
nt work on tracking sys-  
is aimed chiefly at using  
5-micron region for more  
ive operation against such  
temperature, gaseous radi-  
as targets seen otherwise  
from the tail aspect.

sign problems involving  
ivity, discrimination, look  
, and multiple-target ca-  
ty are being tackled with  
optical and mechanical  
ods. For the 3-5-micron  
n, you need optical mate-  
with suitable transmission  
characteristics for tracking as  
as other types of systems.  
e detection systems must  
through air at supersonic  
s, you're faced with the

more on next page



# Operations Research

Mathematicians, Physicists and Engineers with experience or strong interest in Operations Research on large-scale automated systems will be interested in the major expansion program at System Development Corporation.

SDC's projects constitute one of the largest Operations Research efforts in the history of this growing field. The projects are concerned primarily with man-machine relationships in automated systems in a number of fields, including air operations. The application of new and advanced digital computer techniques is particularly important in optimizing these man-machine relationships.

Senior positions are among those open. Areas of activity include: Mathematics, System Analysis, Forecasts, Cost Analysis, Operational Gaming, Design Analysis, Performance Evaluation.

Those who have professional questions or desire additional information are invited to write Dr. William Karush, Head of the System Development Corporation Operations Research Group at 2424 Colorado Avenue, Santa Monica, California.

## "A THEOREM IN CONVEX PROGRAMMING"

A paper by Dr. Karush is available upon request. Address inquiries to Dr. William Karush at System Development Corporation.



## SYSTEM DEVELOPMENT CORPORATION

*An independent nonprofit organization • Santa Monica, California*

## INFRARED

problem of providing a reliable temperature-resistant window over the optical system.

Underlying the general problems of IR is the need for adequate data on the radiative levels of targets and backgrounds. Special radiometric instruments have provided useful data on the IR output of various aircraft and missiles. Generally, the problems of radiometric design resemble those of operational IR equipment.

Some of the major IR components are still being developed. Perhaps the most critical of these is the detector.

Though not as commonly used as the more conventional phototubes, PbS detectors are in a satisfactory production state. Such problems as stability with time and resistance to wide temperature ranges and other ambient conditions have been solved.

In some of the most recent designs, there's a trend toward detectors of more elaborate configuration for the 3-5 micron region. Several of these types are in limited production under development. General production techniques for the detectors haven't progressed to the level of the PbS units.

The most advanced detectors, in terms of sensitivity, response speed, and spectral response, are diffused-junction indium antimonide, lead selenide, p-type germanium, and lead telluride. In their most sensitive forms, these elements must be operated well below ambient temperatures.

For adequate sensitivity, diffused-junction indium antimonide, germanium, and lead telluride must be at temperatures approaching that of liquid nitrogen. Some detectors, such as lead selenide, PEG type indium antimonide, and photoconductive indium antimonide, can be operated at room or solid CO<sub>2</sub> temperatures. However, these units are available only in limited quantities and at high prices.



## Requirements for Design of and Track Systems

Search System	Track System
20-180 deg 0.1 to 4	1-20 deg 4 to 100
about 1 deg 10 to 50 or more multiple	about 0.05 deg 5 to 10 one only
position (2 coord.); intensity; size (2 coord.); color presentation	position (2 coord.); rate of change of position holding one target in presence of several

The low temperature operating requirements of the 3-5-micron detectors pose the problem of a practical cooling method. Since detectors and optics are generally small, the cooling system also must be small. Several approaches to getting a cooling device producing —196 deg C and below are being worked on. Liquid nitrogen refrigeration using miniature Joule-Thomson expansion looks promising.

What is really needed is a light, self-contained package that can operate on call. Problems of reliability for long periods of operation must still be faced.

Optical materials usable as refractors in the 3-5-micron region are being widely sought. The substances receiving the most attention include germanium, silicon, arsenic trisulfide, calcium aluminate glass, and several in the crystalline group (synthetic sapphire, magnesium oxide, and the alkali halides). As they have a high index of refraction, low reflectance surface coatings have been developed for optical elements.

With the use of large aperture optical systems, you face the problem of building sufficiently large mirrors. Ways of making these large elements with minimum weight and ade-

more on next page



## Baby, it's **HOT** inside .....



No matter where it comes from . . . ultra-high angular velocities, skin-friction, conduction or radiation from the burners . . . today's airborne bearings spin in temperatures that approach ever closer to the softening point of conventional steels.

Unceasing research work here at Rollway strives for new understanding and control of limiting forces . . . and for practical metallurgical combinations that will enable

aerodyne engines to fly faster, higher and further with less mechanical friction drag.

Rollway service extends all the way from down-to-earth estimates of lead time to closely-held schedules of delivery dates. Maybe we have what you want now on test. Costs nothing to find out. Just write or wire Rollway Bearing Co., Inc., 582 Seymour St., Syracuse 4, N. Y.

● Typical of Rollway R & D work is this hydraulic control bearing for the McDonnell "Voodoo" jet, featuring a broached, non-separable inner race.

# ROLLWAY<sup>®</sup>

## BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • Los Angeles • San Francisco  
Circle No. 172 on Reader Service Card in Product Review Section

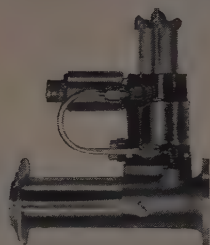


# *proved reliable*



## *duct couplings / duct supports*

Couplings provide metal-to-metal seal, fast disconnects, for high pressure, high temperature air ducts. Standard diameters 1" to 7", specials to 36". Separate or integral duct supports. Many materials.



## *pneumatic controls*

Multi-function weight-saving air valves and regulators manufactured to missile tolerances. Adequate staff for fast design and production changes.



## *Platular\* heat exchangers*

Combine efficiency of plates with strength of tubes into new economical modular design. Can fit into cramped, odd-shaped spaces in missiles and high performance aircraft for great variety of applications.

\*Trademark of Surface Combustion Corporation.



## *ground support liquid heaters*

Standard units for vehicle, space, and fuel transfer applications. Available in capacities from 90,000 to 1,000,000 Btu/hour and can be combined easily for greater output. Now in service in a wide range of ground support equipment.

Janitrol development and test facilities provide proof in advance of reliable performance in service.

Contact your Janitrol representatives when you need components or systems for heat transfer or air control. Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 16, Ohio.



pneumatic controls • duct couplings & supports • heat exchangers  
Circle No. 173 on Reader Service Card in Product Review Section

## INFRARED

quate mechanical stability being looked into.

Aspheric optical systems have the big advantage of sign flexibility, which spurred efforts to develop these specialized components. Replicating techniques, using highly stable plastics, are being tried.

The window, an integral part of the optical system, must be of a material that has exceptional optical quality; it is mechanically stable in supersonic wind-streams. Engineers are working on the problem with silicon, synthetic sapphire, and magnesium oxide, among other materials.

The multi-layer interference filter, so effective for a visible spectrum, is being applied to IR in a number of important designs. The adaptability of this technique to various filter requirements makes it most useful to the designer.

Electronic processing circuitry, an important part of the IR device, is receiving much attention. Basically, it accepts the signal generated by the detector and processes it to a form acceptable by the presentation system. Engineers are looking for new techniques that will give optimum characteristics in all applications. Electronic filtering is being tried to get maximum use of the signal while reducing the unwanted noise background.

Since it has to meet a variety of operating environments, the processing circuitry is usually custom-designed. To meet the need for small size and low power consumption, transistorized circuits are being developed.

At the output end of most current IR systems is some means of presenting the data. Closed-loop systems such as trackers use the output data for reorienting their optics. However, in search, surveillance, and recon systems, the output information is presented visually. Typical of the special presentation devices that are



# Firth Sterling ...

PIONEER IN POWDER AND MOLTEN METALLURGY

...ing more popular are  
age-type cathode ray tubes  
two-dimensional indicat-  
tubes (e.g., National  
on's Videotron).

At the same time, we're im-  
ving techniques for re-  
ding the output of scanning-  
t devices on film. Magnetic  
es continues strongly as a  
ful medium for recording  
a from IR scanning systems.  
eral special indicating des-  
es using flashing lamps syn-  
onized with the scan rate  
oss the target image have  
n developed. These give  
a more direct and easily  
rpreted presentation.

sensitivity limit is  
liation noise

Until we're stopped by con-  
ions outside the IR system,  
ther development of sys-  
as and components prom-  
s big benefits for the state of  
art. Detectors, for in-  
nce, can take improvements  
sensitivity up to the point  
which they are limited by  
incident radiation noise. In  
best operational detector  
produced, we're still short  
this limit by no less than  
actor of five.

Present optical materials are  
e for improvement in spec-  
l transmission and mechan-  
l properties even under  
rent operational conditions.  
ector cooling equipment,  
o, is still in a relatively early  
ge of development. We can  
ake it more reliable, and  
ore flexible.

Our information processing  
stems have a long way to go.  
on-linear devices perhaps  
ll improve the overall S/N  
io. Further work on presen-  
ion techniques can't help  
t make for more effective  
e of output data.—End

Turn back to beginning of  
next article on page 28



## WANTED:

## new applications for high temperature alloys

Charted above are high temperature alloys produced by Firth Sterling metallurgy to meet today's specifications in the aircraft and missile industry. There are, no doubt, applications for these which do not yet exist—just as there are applications for which no satisfactory materials have been developed. We'd like to know your needs—and apply our experience to your problems.

For over 68 years, Firth Sterling metallurgists have pioneered the development of tougher, more heat-resistant metals. Their experience in all

three melting methods: air arc, consumable electrode (STERCON) and induction vacuum (STERVAC) is exceptional. And this important technological "know how" is being applied to newer metals such as Zirconium.

*If your requirements involve the engineered performance of alloys at higher and higher temperatures, our background in this field could prove helpful. Please let us hear from you. Firth Sterling, Inc., Dept. 15A, 3113 Forbes St., Pittsburgh 30, Pa. Offices and warehouses in principal cities.*



Trade Mark \*General Electric Co. • \*\*Pratt & Whitney Div., United Aircraft Corp. • \*\*\*Utica Drop Forge & Tool Div., Kelsey Hayes Co.  
†Allegheny Ludlum Steel Corp.

"Your Future is Great in a Growing America"

PRODUCTS OF **Firth Sterling** METALLURGY

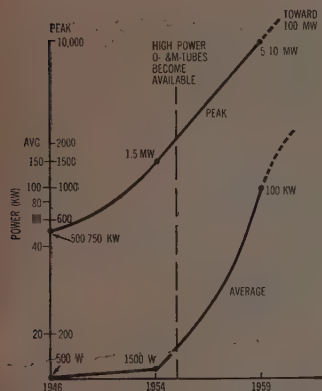
HIGH SPEED STEELS • TOOL & DIE STEELS • STAINLESS SPECIALTIES • HIGH TEMPERATURE ALLOYS  
SINTERED TUNGSTEN CARBIDES • HEAVY METAL • CERMETS • CHROMIUM CARBIDES  
ZIRCONIUM • STERVAC & STERCON SUPER ALLOYS



Circle No. 174 on Reader Service Card in Product Review Section



Continued from page 25



**MICROWAVE POWER** has been on the upswing over the years. Greatest boost came with development of axial beam (O-type) and crossed-field (M-type) tubes. Average power has increased more sharply than peak power. Reason is that high peak powers are limited by component breakdown. Design accent has been on getting more energy out by upping average powers.

gree of beamwidth. In turn this adds up to a problem of energy generation by the transmitter and one of focusing by the antenna.

Modern long range radars are putting out peak powers in the tens of megawatts and average powers in the hundreds of kilowatts. Soon, it is expected, these powers will approach 100 Mw peak and one megawatt average. Developments in high power klystrons, wave tubes of the O- and M-types, and other crossfield devices such as the platinotron have paved the way for these tremendous powers (see *AvAge*, "New Breed of Microwave Tubes," Apr. '58, p. 22).

The days of the magnetron—except in simple radars—are numbered. Because of their high power-weight ratios, magnetrons will have a longer life in airborne and portable ground systems, but even here they are being ousted rapidly.

Almost all new high power ground systems and many airborne ones are using oscillator-power amplifier combinations of either klystrons or wave

## AMP TAPER TECHNIQUE



(A) A-MP "53" SERIES TAPER PINS...insulated solid, screw machined or uninsulated formed pins to mate with tapered receptacles. Both types provide noise-free, low resistance electrical characteristics.

(B) A-MP "53" SERIES TAPER BLOCKS...are available in either solid blocks or two-piece blocks...10 or 20 cavity series...single or dual insert.

(C) A-MP TAPER TAB RECEPTACLES...accommodate flat tabs employing the taper key principle...feature standardized tapered section to fit relays, stepping switches, multiple connectors and other electronic components.

(D) A-MP MINIATURE TAPER PIN RECEPTACLES...eliminate tedious and costly operations of soldering leads to miniature connectors...use A-MP "37" Series Pins.

Bulletin Number 77

## AMP PATCHBOARD TECHNIQUE



**A-MP PATCHCORD PROGRAMMING SYSTEMS AND PANELS** offer tremendous versatility and flexibility. Exclusive feature of A-MP Systems is wiping action of pins against springs for clean contacts. A-MP Universal Patchcord Programming Systems and Panels are excellent for digital computers, data processing equipment and automatic test equipment. A-MP Shielded Patchcord Programming Systems and Panels are excellent for analog computers, telemetering equipment, test equipment and other low level applications where reliable shielding is required. Patchcords are made in a complete series for all programming requirements.

**A-MP "240" SYSTEMS**...offer complete reprogramming in seconds in airborne applications. The compact "240" System weighs 3¼ pounds and features 240 patchcord receptacles for maximum program combinations. It, too, features the exclusive wiping action to assure optimum electrical contact at all times.

Bulletin Number 58

Information concerning any termination problem will be forwarded on request. For literature on the above products, write, giving bulletin numbers desired, to:

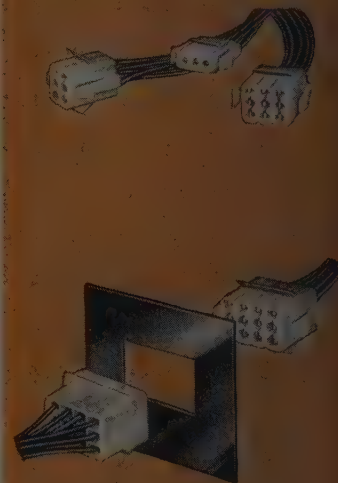
# AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

Circle No. 175 on Reader-Service Card for Bulletin 81  
Circle No. 176 on Reader-Service Card for Bulletin 24  
Circle No. 177 on Reader-Service Card for Bulletin 37

AMP

## AMP-LOK MULTIPLE CONNECTOR



**AMP-LOK CONNECTORS**...are made in 3, 6, 9, or 12 circuit units...the most versatile multiple connectors available to the electronics industry. Self anchoring units require no extra mounting parts for through-panel applications. All contacts are identical and self cleaning...recessed for safety. Finger grip engagement and disengagement of housing which is polarized to eliminate circuit error. AMP-lok will accommodate a wide range of panel thicknesses...may be color coded. AMP-lok may also be used with complete safety as a free hanging multiple connector.

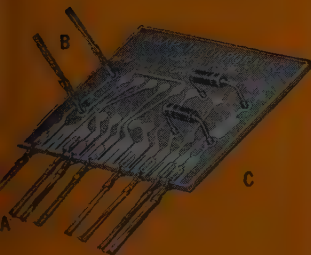
Bulletin Number 45



# TECHNIQUES . . . SPECIFY



## PRINTED CIRCUIT TECHNIQUE



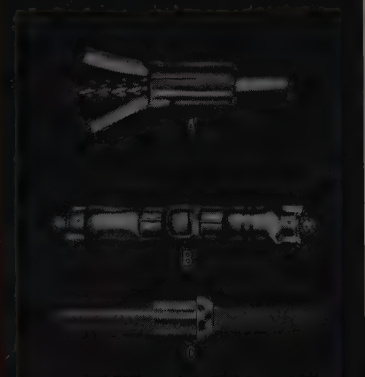
**(A) AMP-EDGE TERMINALS . . .** assure excellent electrical contact with friction grippage and positive wiping action . . . apply easily to any section of the perimeter of the printed circuit board . . . reduce cost of application to wire conductor and to board.

**(B) AMP-IN TERMINALS . . .** eliminate these leads during solder-dip operation . . . promote good capillary action during solder dipping . . . accommodate solid or stranded conductors . . . are self retaining and self-aligning.

**(C) AMP COMPONENT TIPS . . .** prevent movement of components during solder dipping cycle . . . permit bridging or offsetting of components . . . protect semi-conductor leads from solder dipping heat . . . eliminate need for eyelets and thru-plating on two-sided boards, by excellent solder wicking characteristics and uniform solder deposit.

*Bulletin Number 81*

## SHIELDED WIRE PRODUCTS



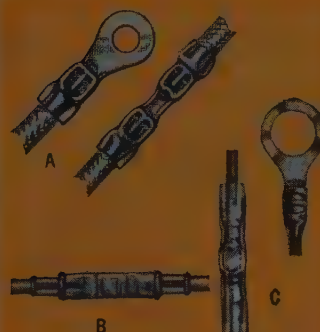
**(A) TERMASHIELD SHIELDED WIRE FERRULES . . .** assure positive ground in a wire shield . . . eliminate solder, danger of burning insulation and uncertain attachment . . . isolate one piece construction . . . accommodate one or more grounding wires.

**(B) TERMASHIELD SHIELDED WIRE SPLICES . . .** join sections of shielded wire so that both the inner conductors and outer shields are firmly spliced with the two effectively insulated. They eliminate multi-stage assembly or soldering . . . color coded for matching with application loading and wire sizes.

**(C) TERMASHIELD 7MM SHIELDED CABLE FERRULES . . .** permanently ground shielded high tension cables . . . prevent wire damage during attachment . . . won't loosen or vibrate to cause poor ground or rf noise . . . remove danger of sparking . . . offer easy, four-step attachment . . . seat precisely into applicable joints.

*Bulletin Number 24*

## TERMINALS AND SPLICES



**(A) STRATO-THERM TERMINALS AND SPLICES . . .** for high temperature and heat resistant requirements . . . accommodate a wide range of wire sizes either solid or stranded or both . . . with or without fully circumferential wire insulation support as desired.

**(B) CERTI-SEAL MOISTURE PROOF WINDOW SPLICES . . .** seal out vapors and fluids even at altitude to assure dry splice . . . accommodate over 100 insulation thicknesses . . . resist heavy vibration and shock.

**(C) OTHER A-MP TERMINALS AND SPLICES . . .** designed for the most diverse circuitry requirements . . . stringently tested for corrosion resistance, vibration resistance, conductivity and long life . . . ideal for all types of electronic equipment.

*Bulletin Number 37*

## RADAR

tubes. In non-microwave radars (200-900 mc), in which you'll find today's super-power sets, triode oscillator-power triode or tetrode combinations are used. Megawatt (peak) microwave amplifiers are available for the L- and S-bands and high kilowatt amplifiers of the same families for the X- and K-bands.

In addition to high power, oscillator-power amp combinations have excellent pulse-to-pulse frequency stability and can change frequency rapidly. Pulse-to-pulse coherence is especially necessary in some of the sophisticated signal enhancement and countermeasures schemes in use and planned and also for Doppler radars and radars equipped with modern MTI (moving target indicator) system.

The tuning ranges of high power klystrons are usually one or two per cent electronically and up to around 15 per cent mechanically. In high power backward and forward wave (TWT) amplifiers, electronic tuning of up to 15 per cent can be had. These transmission bandwidths are too small to suit the military, which would like to get at least 50 per cent tuning—for greater counter-countermeasures flexibility. This is one area in which much of the midnight oil is being burnt.

## Klystrons in use have medium power

Some power klystrons are used today in aircraft and missiles, but they are medium power types. Here weight has been traded off for pulse stability (as for airborne MTI).

Hughes Aircraft is working on a master oscillator-power amplifier (MOPA) transmitter for its newest interceptor fire control system that, it claims, will give some 20 times more power than the present average as well as the stability needed for pulse Dop-

*more on next page*

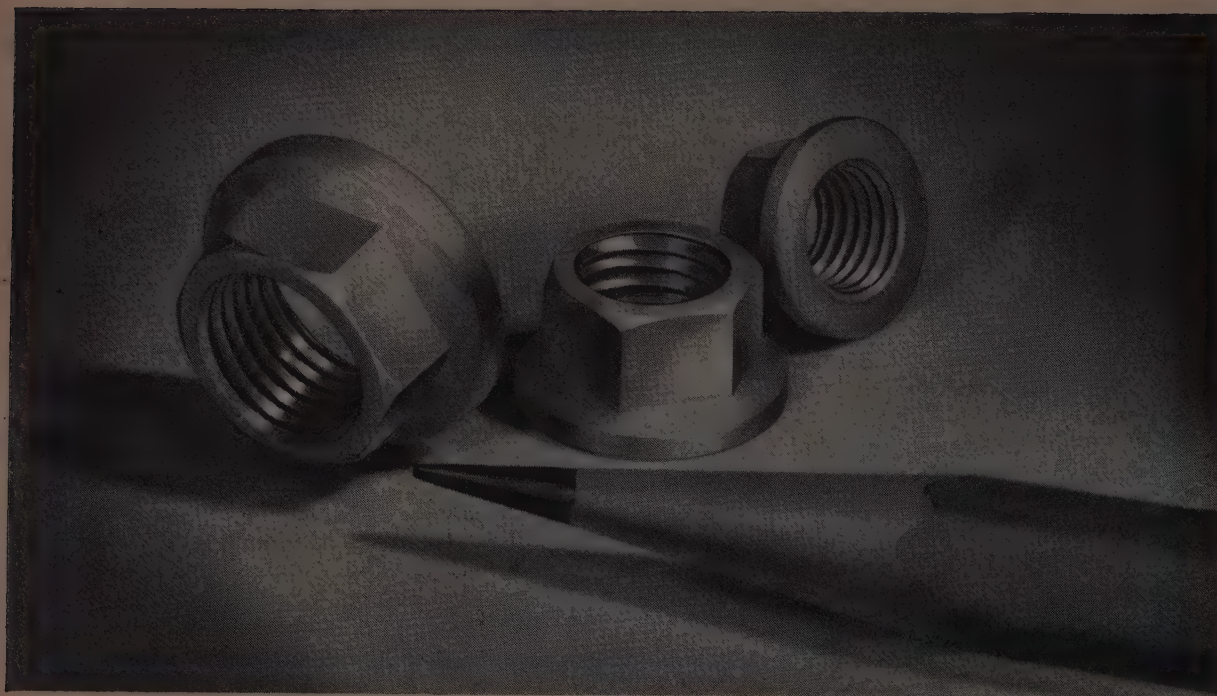
**A-MP products and engineering assistance are available through wholly-owned subsidiaries in: Canada • England • France • Holland • Japan**

Circle No. 178 on Reader-Service Card for Bulletin 77

Circle No. 179 on Reader-Service Card for Bulletin 58

Circle No. 180 on Reader-Service Card for Bulletin 45





New FN-12 Series Featherweight Locknuts provide 125,000 psi minimum at temperatures up to 550°F, yet weigh 12% to 72% less than comparable sheet metal (NAS 679) and AN Series nuts. The FN-12 is installed with standard tools, incorporates new burr-free locking feature which permits highly accurate torquing.

## New SPS Featherweight locknuts save you up to 72% in locknut weight

Smaller hex also requires less installation area  
—helps you design more compact bolted joints

Designed for fastening structural skin and panel assemblies, the new SPS FN-12 Series Featherweight Locknut offers you weight savings of 12% to 72% over widely used sheet metal and AN Series nuts. Yet despite its light weight, the cold forged FN-12 sacrifices none of the static or dynamic properties of its heavier counterparts. Meeting all requirements of MIL-N-25027, it has a tensile strength exceeding 125,000 psi. Its vibration resistance is 150% of specification minimum. And it gives greater bolt tension-tension fatigue strength than any other lightweight locknut tested.

Besides offering you valuable weight savings combined with high strength and reliability, the FN-12 locknut, because of its new configuration, can be installed closer to vertical bulkheads than any other aircraft nut now in use. This permits further weight reductions through miniaturization of joints to be fastened.

FN-12 Series Featherweight Locknuts are available in heat treated alloy steel in sizes #4 through 3/8 in. They are furnished cadmium plated, with optional molybdenum disulfide coating. For complete information request new Bulletin 2426. Aircraft/Missiles Division, STANDARD PRESSED STEEL CO., Jenkintown 54, Pa.

We also manufacture precision titanium fasteners / write for free booklet

**SPS** Jenkintown • Pennsylvania  
Standard Pressed Steel Co. • The Cleveland Cap Screw Co. •  
Columbia Steel Equipment Co. • National Machine Products Co.  
• Nutt-Shel Co. • SPS Western • Standco Canada Ltd. •  
Unbroko Socket Screw Co., Ltd.

### WEIGHTS OF FN-12 AND COMPARABLE LOCKNUTS

(all weights expressed as pounds per 1000 pieces)

Size	FN-12	NAS 679*	% Weight Saved by FN-12	AN Series†	% Weight Saved by FN-12
# 4-40	0.4	0.8-1.0	50%-60%	1.3	69%
# 6-32	0.7	1.3-1.7	50%-60%	1.8-2.5	61%-72%
# 8-32	1.2	2.1-2.5	43%-52%	2.8-4.2	57%-71%
# 10-32	1.5	2.5-2.8	40%-47%	3.3-4.6	55%-67%
1/4-28	3.5	3.9-4.7	12%-26%	5.4-8.5	35%-59%
3/8-24	5.4	6.4-7.2	16%-25%	8.7-11.8	38%-54%
3/8-24	7.3	9.3	21%	11.5-19.5	37%-63%

\*Range of four most commonly used sheet metal nuts of NAS 679 type

†Range for AN 363, 364, 365

### HIGH RELIABILITY

SPS research is continually developing fasteners with higher standards of predictable performance. By installing SPS high-reliability fasteners in your assemblies, you increase overall product reliability.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

### RADAR

Table 1: The Best in  
Low Noise Crystal Mixers

Frequency Range (kmc)	Crystal	Microwave Mixer- Amp No. Figure (db)
3.95-5.85	1N23EMR	5.8-6
2.6-3.95	1N21EMR	5.8-7
1.7-2.6	1N21EMR	6.0-7
1.12-1.7	1N21N	5.0-6

• IF amplifier used Cascade GL-6299 triode in front ends with average noise figure one decibel at 30 mc. Until the advent of parametric amplifiers, these receivers were considered to have the lowest noise figure possible within state of the art. Figure from Rome Air Development Center.

pler. (Present systems use 250 kw-peak mechanically tuned magnetrons.) This MOPA is believed to be a backward wave oscillator working into a string of TWTs.

The development of high power switch tubes and diode has kept pace with power increases in transmitters. Hydrogen thyratrons are still being used, but their switching capabilities have increased several orders of magnitude in power. The military is sponsoring several development programs on high power hard tube and magnetic modulators.

### Statistical concepts put into circuit form

The application of statistical concepts may prove to have the greatest influence on future radar designs (see *S/A "Information Theory Plays Key Role in Radar Design," Dec. '58, p. 138*). Since one must consider random variables—such as scintillation, glint, clutter, noise, and jamming—the radar problem requires statistical analysis for accurate solution. While this has long been realized, it has been only recently that designers found ways of applying statistical concepts to success


more on page 9





*This is*  
**BJ ELECTRONICS**

## Perception

Looking for an electronics organization with an intuitive grasp of your requirements? Consider BJ Electronics' decade of experience gained in successful development of such diverse products as: Vibrotron transducers and accelerometers, radio-frequency test instrumentation, atmospheric sounding rockets, mobile radar test vans and Northam miniature magnetic tape recorders. Here's a well-equipped, highly creative engineering team able to fulfill your specifications without losing time or sacrificing quality. Consider your problems, then...consider our perceptive ability to solve them!  Write for facilities brochure. BJ Electronics, Borg-Warner Corporation, 3300 Newport Boulevard, Santa Ana, California.





## Reliable Aircraft depend on Reliable Hose

Photo courtesy Pan American World Airways.



**M**ODERN military jets have proven Fluoroflex®-T (Teflon®) hose in rugged service. Now the fast new commercial airliners use this same hose—for safety and economy.

Fluoroflex-T hose, with patented, specially compounded tube of Teflon, is non-aging—has no shelf or service life limit. Originated by Resistoflex, Fluoroflex-T was the first Teflon hose and it has been flying for five years on all types of jet and reciprocating engines and aircraft. It is available with compression-type fittings or "Seal-Lock\*" reusable fittings.

Always specify the hose with highest performance and capabilities—not only for safety's sake, but for savings as well. Send for details. Write Department 190, RESISTOFLEX CORPORATION, Roseland, New Jersey. Other Plants: Burbank, Calif.; Dallas, Tex.

\*T.M., Pat. No. 2,853,319

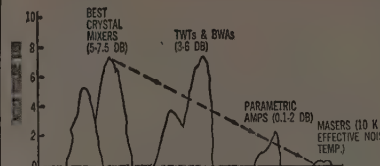
© Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.  
© Teflon is DuPont's trademark for TFE fluorocarbon resins.

Originators of high temperature fluorocarbon hose assemblies

# Resistoflex

Circle No. 183 on Reader Service Card in Product Review Section

## RADAR



**NOISE FIGURES** have been progressively lowered. Crystal mixers and the "medium-low" noise TWTs are available. Others are still in various stages of development. A limited number of PN junction parametric amplifiers is being used in special applications.

ful circuits and hardware.

One of the best-known techniques here is pulse compression. With PC, the designer can use relatively long transmitted pulses to get higher average powers without sacrificing the range resolution and high  $E/N_0$  of a short pulse, high peak power system. By getting away from high peak powers, he can put more energy on the target without running into arcing and voltage breakdown problems.

A common PC method is to vary the RF of the transmitted pulse. While the pulse appears to the generators as, say, a 10-usec pulse, because of the RF variations the receiver might see a train of one-usec pulses.

Matched filters, in various forms, are used in receivers to correlate the incoming wave's shape to that of the outgoing wave and so distinguish from false signals and noise.

Another statistical technique for signal enhancement is signal integration (loosely also a form of PC). The aim is to delay and integrate target returns over a period of time. Since the desired signals are regular in character, they will tend to add; the noise, being random, will tend to cancel.

There are two forms of integration: post detection (video) and predetection (at RF or IF). The former has been used for a number of years

## Flight Data and Control Engine

Cross new frontiers in system electronics at The Garrett Corporation.

High-level assignments in the design and development of system electronics are available for engineers in the following specialties:

### 1. ELECTRONIC AND FLIGHT DATA SYSTEMS AND CONTROLS

A wide choice of opportunities exists for creative R&D engineers having specialized experience with control devices such as: transducers, flight data computers, Mach sensors, servo mechanisms, circuit and analog computer designs utilizing transistors, magamps and vacuum tubes.

### 2. SERVO-MECHANISMS AND ELECTRO-MAGNETICS

Requires engineers with experience or academic training in the advanced design, development and application of magamp inductors and transformers.

### 3. FLIGHT INSTRUMENTS AND TRANSDUCERS

1) **DESIGN ANALYSIS** Requires engineers capable of performance analysis throughout preliminary design with ability to prepare and coordinate related proposals.

2) **DEVELOPMENT** Requires engineers skilled with the analysis and synthesis of dynamic systems including design of miniature mechanisms in which low friction freedom from vibrational effects and compensation for thermo expansion are important.

### 4. PROPOSAL AND QUALITY ENGINEER

For specification review, proposal and quality analysis and report writing assignments. Three years electronic, electrical or mechanical experience required.

Forward resume to:

Mr. G. D. Bradley

**THE GARRETT CORPORATION**  
9851 S. Sepulveda Blvd.  
Los Angeles 45, Calif.

DIVISIONS:

AiResearch Manufacturing—Los Angeles  
AiResearch Manufacturing—Phoenix  
AiResearch Industrial  
Air Cruisers—Airsupply  
Aero Engineering  
AiResearch Aviation Service

Circle No. 184 on Reader-Service or send personal resume direct to address. GIVE HOME ADDRESS.

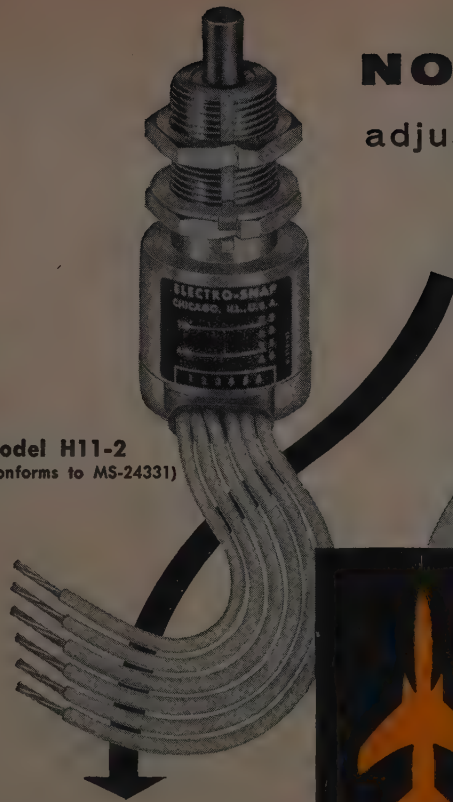


**NOW...** sealed dependability in an adjustable, rugged, environment-free



## LIMIT SWITCH

**Model H11-2**  
(Conforms to MS-24331)

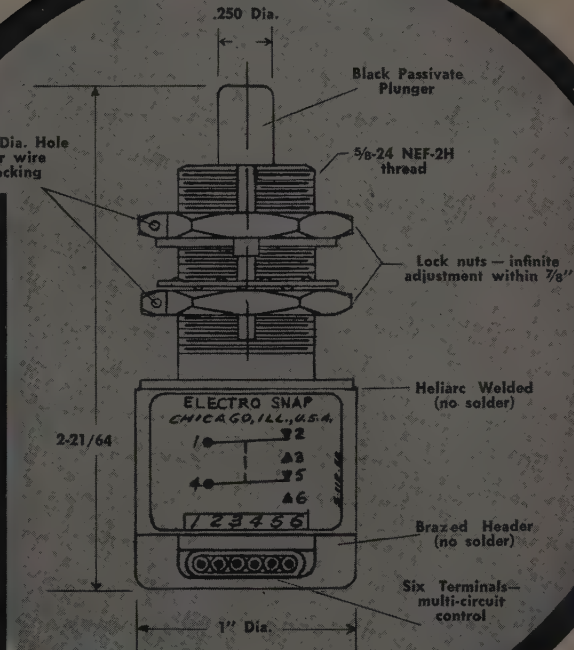


- Use for any exposed control or indicating application on aircraft or machines.
- Corrosion resistant — Stainless Steel or Monel used for all exposed metal parts.
- Heliarc welded for positive sealing and added strength.
- Meets all requirements of Immersion Test MIL-E-5272, Procedure I.
- Header is brazed (not soldered)

### operating characteristics

Contact Arrangement.....	2—S.P.D.T.
Pretravel .....	.040 Max.
Movement Differential .....	.020 Max.
Overtravel .....	.250 Min.
Operating Cycles .....	25,000 Min.
Break Distance .....	.010 Min.
Difference of Operating & Reset Pt. Between Each Pole.....	.010 Max.
Operating Force .....	9± 3 Lbs.
Overtravel Force .....	30 Lbs. Max.
Release Force .....	4 Lbs. Min.
Electrical Rating—Sea Level to 100,000 Ft. ....	28 VDC, 4A. Res. 2 A. Ind.—4A Motor
Ambient Temperature Range.....	—100° to +221° F.
Weight .....	2¾ Oz. Approx.

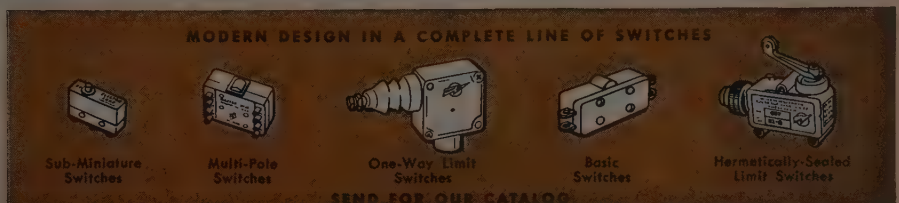
- Mount anywhere — through one mounting hole. Infinitely adjustable within 7/8" — wire locking.
- Multi-Circuit Control. 6 separate terminals permit many circuit combinations.
- High operating and overtravel force provides positive ice-breaking characteristics to assure perfect, dependable operation.
- Light and Compact . . . yet rugged and impervious to all environment conditions.



### ELECTROSNAP CORPORATION

4220 Ross Street VAN BUREN 6-3100  
Chicago 24, Illinois TWX No. CG-1400

For full details, write for Data Sheet EC-6. And, for information on the many other Electro-Snap sealed switches.



Circle No. 185 on Reader Service Card in Product Review Section



Do you know about  
Gask-O-Seals?

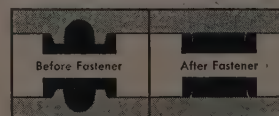
## THIS Gask-O-Seal EXCEEDS HERMETIC SPECS!

Gask-O-Seals often equal or exceed specification for hermetic sealing. The one shown here, for instance, has eight sealing points and is on one of our newest missiles. The leakage rate is less than the original hermetic seal specification called for which is about as perfect as any seal can be.

Gask-O-Seals are high and low pressure static seals which require NO groove machining to accommodate. A flat surface with only a 125 RMS surface finish is all you have to provide to get positive sealing with a Gask-O-Seal.

There are many other outstanding features about Gask-O-Seals: Limited area for fluid attack, no loss of structural strength, rigid, easy to install and replace, no tolerance build-up possible in seal cavity, etc.

Why not find out about Gask-O-Seals and the other seals of Parker Seal Company's "O-Seal Family"—by the makers of Parker O-rings.



# Parker

## SEAL COMPANY

CULVER CITY, CALIF. • CLEVELAND, 12, OHIO

A DIVISION OF **Parker Hannifin** CORPORATION

(Formerly F. C. Wolfe Co. & Rubber Products Div. of Parker Appliance Co.)

plexity can be cut, signal enhancement should find use in shorted range systems and airborne radars.

An important effort is underway to improve performance by lowering the figure (NF). As with power, this is largely a function of component development.

First came better circulators and "quieter" tube preamps and IF strips. This brought minimum figure less than 7½ db (see Table I).

Then came the TVT which gave lower NFs than even the best crystal mixers and, at the same time, provided RF amplification over an octave of bandwidth. Most of the newer receivers in development and on the drawing boards are designed around TWTs. Developmental TWTs and backward wave amplifiers show promise of dropping noise to four decibels.

The highest hopes, however, are pinned on the solid state UHF and microwave amplifiers of the parametric maser types and also on vacuum tube electron stream parametric amplifiers. The maser, for instance, is theoretically noise-free. On the other hand, programs underway at USAF Rome (N. Y.) Air Development Center (RAI) show NFs of 1-2 db have been predicted for PN parametric amplifiers in the S-, L-, P-bands. For next year, NFs of 0.1-0.5 db are predicted.

Table II also reveals the main drawback of the solid state amplifiers: narrow bandwidth. Their bandwidths have to be increased substantially if designers are to be able to take full advantage of the low noise qualities. Judging from the large number of top engineers engaged in parametric amplifier and maser research, the chances for solving this problem are good.

Airborne Instruments Laboratory, for example, reported getting an eight per cent bandwidth



0 db gain at 400 mc with a N junction parametric amplifier operated in the sum-frequency mode. Many of the diverse modes of maser and parametric amplifier operation are yet to be fully explored.

The electron stream parametric amplifier, a four-inch vacuum tube jointly discovered by Stanford U. and Zenith, seems to have unlimited bandwidth potential. A prototype showed 30 db gain with a one decibel NF. Chances look good for this device in future radar designs.

The maser probably won't be used widely in active radars. One of the main drawbacks is that its crystal element must be kept at liquid helium temperatures. Another is that it requires a sizeable magnetic field. Also, it is quite difficult to align and tune. Most radar designers see the main use of the maser in spe-

cial-purpose equipment such as radio telescopes.

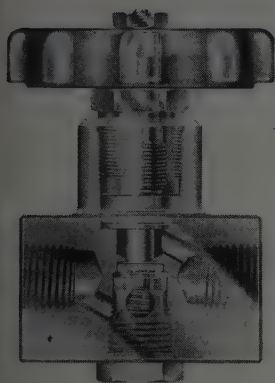
Low noise receivers also will pose a new set of problems. To put it briefly, by making a device sensitive to microscopic signals, the designer also makes it sensitive to microscopic noise sources ignored by present "noisy" receivers.

In conventional radars, the receiver contributes most of the receiving system noise. In receivers with effective noise temperatures of a few hundred degrees or less, most of the noise will be contributed by what the antenna sees and by resistive losses in the antenna, the waveguide, and connecting joints. These last should prove especially troublesome, since they both attenuate signals and generate noise.

Four sources of noise that is picked up by the antenna will have to be reckoned with: (1)

*more on next page*

## MANUAL SERIES 900. PRECISION SHUT-OFF VALVE...



### *featuring...*

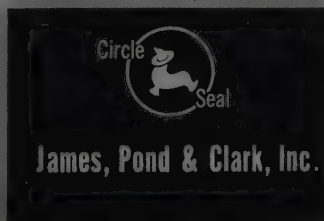
dead tight shut-off... accurate flow control... minimum restriction to flow... recommended for 0-3000 psi with virtually all non-corrosive liquids or gases... for ground support equipment and in test stands

### *series T900...*

featuring quick-acting toggle lever handle... quick snap opens, quick snap closes, dead tight. O-Ring absorbs closing shock to system... positive locking cam holds valve open or closed... for ground support equipment and in test stands

Complete engineering data available. Write today!

East Foothill Boulevard/Pasadena, California



**James, Pond & Clark, Inc.**

Circle No. 106 on Reader Service Card in Product Review Section



**probing beyond present knowledge... opening new corridors into the unknowns of space...** *THIS is the exciting task of the professional minds at MARTIN-DENVER. Post-Titan weapon systems, space vehicles, and the development of entirely new concepts in space travel requires the talents of exceptional people. Perhaps this stimulation and association suits your objectives in achieving outstanding professional status. If so... Write to N. M. Pagan, Director of Technical & Scientific Staff, Martin-Denver, P. O. Box 179 (A-1), Denver 1, Colorado.*

**MARTIN**  
DENVER DIVISION

Circle No. 107 on Reader Service Card opposite last page or send personal resume direct to address mentioned above. GIVE HOME ADDRESS





# INSTRUMENTS

FOR RESEARCH AND DEVELOPMENT

## TUBE TESTERS

### AUTOMATIC—CARDMATIC

**MODEL 1230**—Card programmed to automatically set-up predetermined voltages and conditions for each tube under test. Self-calibrating and accurate within 1 to 3% of best known standards for transconductance and plate current measurements. Reject levels set in accordance with military specs. Also permits special purpose tube tests to meet specific circuit requirements. Portable style with cover.

### FIELD SERVICE STANDARD

**MODEL 1575**—Meets Western Electric specifications as a Mutual Conductance tester. 0-60,000 micromhos in 7 ranges. Two separate meters for line and grid bias voltage indications. Has 4 signal voltages. Features new, voltage regulator tube test. Built-in roll chart. Portable style with cover.

### RESEARCH LABORATORY

#### MODEL (Not Illustrated)

**MODEL 1700**—For tube tests under handbook conditions. All voltages and currents are variable and metered (9 meters). 0-60,000 micromhos in 8 ranges. Electronically regulated and metered power supplies.

## OSCILLOSCOPES

### WIDE RANGE—VERSATILE

**MODEL 1810**—5" flat face, post accelerated CRT and illuminated, calibrated screen. 4 mc band vertical amplifier. 10 millivolts peak-to-peak per cm sensitivity. Triggered or recurrent sweeps—variable from 2 cps to 30 kc. Built-in, direct reading, regulated square wave voltage calibrator. AC or DC vertical amplifier inputs.

### INDUSTRIAL'S 5" PORTABLE

**MODEL 685**—Features identical amplifiers DC to 750 kc—1 cps to 750 kc. 0.5 microseconds rise time. Sensitivity—20 millivolts RMS vertical (30 horizontal). Recurrent or triggered sweep. Covers 1 cps to 10 kc in 5 calibrated decade ranges with vernier control of 10 to 1. External sync for triggering and synchronizing the built-in sweep generator.

### 3" RACK MOUNT

**MODEL 387R**—Identical horizontal and vertical amplifiers. Triggered or recurrent sweeps from 1 cps to 100 kc. Slow sweeps (10 seconds or more) with external capacitors. 10 millivolts RMS per inch vertical sensitivity (14 horizontal).

### 3" PORTABLE

**MODEL 385 CSM**—Rugged lightweight designed for field service. Features unitized circuit modules. DC amplifiers (horizontal and vertical) with frequency coverage to 4 mc at .075 RMS volts per inch. 2 MC bandwidth has roll-off per IRE standard. Telescopic light shield and shock mounted carrying case.

### CARD PROGRAMMED SWITCH

Cardmatic automatic or manual multiple switch provides up to 10-trillion variables. Self-cleaning, wiping type contacts rated .00025 ohms nominal (contact-to-pin), current rating is 10 amperes. Prox. 7" x 7½" x 4½" D.

## GENERATORS

### SINE WAVE—SQUARE WAVE

**MODEL 710**—Both sine and square wave outputs in one generator with wide frequency range (20 cps to 1 megacycle in 5 ranges). Sine wave total harmonic distortion below 1%. Hum level better than 90 db down. Square wave rise time less than 0.1 microsecond. Portable—easily adapted to rack mount.

### SQUARE WAVE

**MODEL 1715**—Wide frequency range of 1 cps to 1 megacycle, continuous in 6 decade bands with constantly variable frequency available throughout the entire range. Rise time is 0.02 microseconds. Consistent output level is independent of frequency setting. Electronic regulation of power supply. Includes symmetry control and provision for external synchronization.

## VACUUM TUBE VOLTMETERS

### HIGH FREQUENCY MODEL

**MODEL 1600**—Accurately indicates AC voltages from .05 to 300 volts in frequencies from 20 cps to 700 mc (up to 3000 mc are possible). Includes special thermionic diode probe. Excellent plus or minus DC volts, readability from .05 to 1000 volts. 7-range ohmmeter with practical readability from 0.2 ohm to 1000 megohms. Power supply built-in. Has 1% meter.

### SMALL SIZE VOM

**MODEL 456**—Has full-wave bridge type rectifier circuit. Features a patented automatic (button-reset) overload protection system to hold meter and associated circuits from damage due to accidental overload. 0-1200 AC or DC volts in 6 ranges. Sensitivity—20,000 ohms per volt DC (1000 AC). Resistance—0 to 100 megohms. 5 db ranges (—18 to +57).

## HICKOK-DAWE INSTRUMENTS

True RMS-VTVM—300 microvolts to 300 volts, 5 cps to 500 kc.

Stereoscopes—3 models with wide ranges.

Sound Level Indicators—Portable and laboratory types.

Balancing Machine—For rotating parts (4 oz. to 10 lbs.).

## HICKOK METERS

### Accurate DC and AC Portables

Ammeters, milliammeters, microammeters, voltmeters, millivoltmeters, volt-ammeters, thermometers. Shielded. Accuracy within ½ of 1%—available to 2/10 of 1%.

### PANEL METERS

A complete panel meter line is available in numerous types, styles and ranges to meet every specification. The many special movements developed by HICKOK are: Electrodynamometers, self-contained frequency meters, galvanometers, true logarithmic deflections, ruggedized, long scale subminiatures, and taut-band suspensions with sensitivities to as low as ½ of 1 microampere.

## RADAR . . .

galactic and extragalactic, (2) radio stars, (3) atmospheric absorption, and (4) terrestrial absorption. In general the two decrease and the other increase with frequency, though there are some frequency windows where atmospheric absorption is virtually negligible.

## Radar trend to 200 mc for long ranges

Other important radar trends and developments are:

**Frequency**—For long range search, the trend has been from S-band down toward 200-mc area, because of high power generators and low noise receivers available at lower frequencies. Now, with high power and low noise devices becoming available in the microwave region, the trend should be to go back up to S-band. A good compromise between high resolution and atmospheric absorption seems to lie between 1000 and 6000 mc.

**Polarization**—The variable polarizer, developed at RAD, permits transmission and reception of any polarization—elliptical, linear, or right or left circular.

**Displays**—The trend is toward improved resolution, clarity and dynamic range and toward variable persistence and brighter indicators. Although there is marked trend to use only processed data to display, a variety of special CRTs allows presentation of multiple data, including numerals and symbols on black-and-white and multi-colored displays. Attempts are being made to combine up with CRT presentation that approach photo quality.

In future airborne system displays may be presented on the windshield combining glass with either optics or transparent, thin film CRTs. For large area displays, hopes are pinned on electroluminescence. However, practical devices based on this principle are estimated to be 3-5 years away. In the

more on page 10

# THE HICKOK ELECTRICAL INSTRUMENT CO.

10514 DUPONT AVENUE  
CLEVELAND 8, OHIO

Circle No. 92 on Reader Service Card in Product Review Section



# FULL VOLTAGE RESTORATION IN 1.5 MILLISECONDS

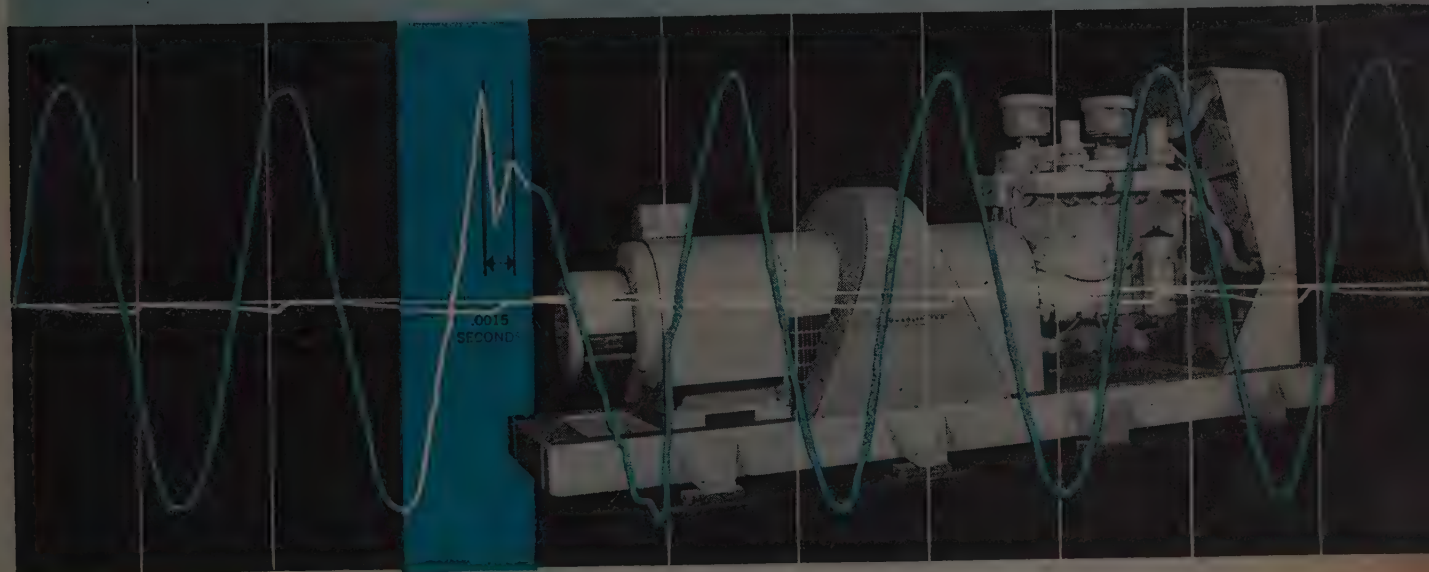
## UNINTERRUPTED **POWER** FROM PRIME TO STANDBY

"Instantaneous" emergency power is just one of the many practical advanced engineering features of ConDiesel's Model UPS.\*

Model UPS\* delivers this outstanding performance... Where even a few vital seconds count, you cannot afford to be without this unit.

Basically the unit consists of a synchronous alternator and flywheel connected to a full diesel, liquid cooled engine, through a dry-type magnetic clutch. When in stand-

by, the diesel does not run, thus greatly reducing operating and maintenance costs. The synchronous alternator and flywheel operate on prime power and when prime power fails or falls below established minimums Model UPS switchgear disconnects commercial power and energizes the magnetic clutch, causing the rotating flywheel to start the diesel. When commercial power returns to normal, the Model UPS will check its quality for a predetermined period, then automatically cut-out and return to its standby condition.



Circle No. 89 on  
Reader Service Card  
in Product Review  
Section



### UNINTERRUPTED POWER SUPPLY

FOR COMPLETE SPECIFICATIONS WRITE TODAY TO

## CONSOLIDATED DIESEL ELECTRIC CORPORATION

POWER EQUIPMENT DIVISION

STAMFORD, CONNECTICUT





We'll test your  
military products for

# HEAT

Heat, load, shock, stress, pressure, vibration. Electrical, hydraulic, pneumatic, structural. Physical, chemical, mechanical. Whatever test is required—microscopic component or mammoth structure—we have what it takes to handle it.

During 12 years of test lab work we've accumulated unique experience and facilities in testing for evaluation, design-qualifications, and acceptance. We understand the most stringent military requirements. And we know how to operate on a systems management basis. Businesslike. On-schedule.

Write or phone: Test Lab Manager, Missile Division Laboratory, North American Aviation, Inc., 12214 Lakewood Boulevard, Downey, California.

**MISSILE DIVISION**   
NORTH AMERICAN AVIATION, INC.

## RADAR . . .

meantime, indirect view storage tubes (e.g., the graphecon family) will have suffice.

**"Computer" storage media in the offing?**

Available direct view storage tubes suffer from limited dynamic range of inputs and low target resolution. "Computer-type" storage media may find use in future systems.

**Counter - Countermeasures.**—Radar designers seem to be one jump ahead of the electronic counter-measures threat. One of their best tools is programmed transmitter frequency variations coupled with a wide band receiver. One technique changes carrier frequency from pulse to pulse. Unique modulation schemes and matched filters allow systems to see through many types of jamming and to discriminate against decoys.

**Airborne Fire Control.**—The C- and X-bands still look best here. Present systems use mechanically tuned magnetrons. Future will use electronically tuned wave tube chains with less peak but some 20 times higher average power. Antennas are getting larger, because more range is needed. Forty inch hydraulically scanned dishes will be seen on future systems. Designers would like to get rid of the dish altogether and replace it with an electronically scanned slot array that is part of the vehicle's structure.

Monopulse tracking will be replaced by pulse Doppler to get 100-200-mile ranges and minimize ground clutter. The advantages of Doppler are partly offset by problems of range ambiguity and design complexity.—End

Turn back to beginning of  
next article on page 26



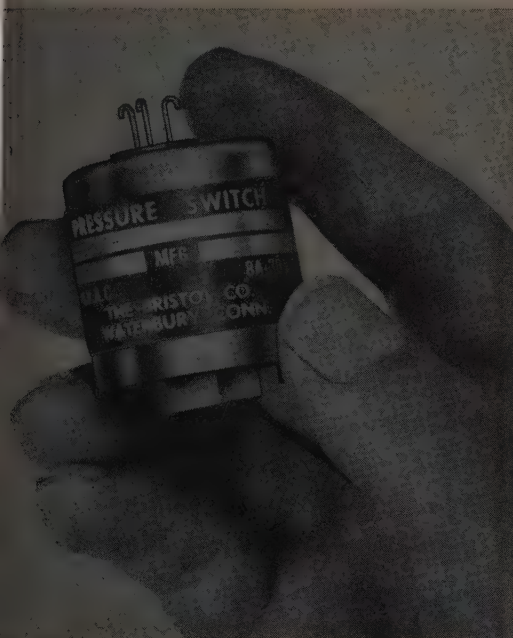
**ristol miniature pressure switch**  
 res ultra-reliable precision pressure element.  
 sive design provides outstanding resistance to  
 k, vibration, acceleration and overpressures.

Bristol miniatures, widely proved in modern aircraft,  
 esigned for switching electrical circuits in response to  
 re changes in air, fuels, lubricants, hydraulic fluids,  
 gases and liquids.

ristol's specially designed Ni-Span element is silver  
 d to the stainless steel base assuring greater reliability  
 ordinary soft-soldered construction. Result: accurate,  
 le, repeatable performance in any position, at tem-  
 res from -65° F to +250° F, and under Mil Spec en-  
 ental requirements.

ite for Bulletin AV2010 on Bristol Miniature Gage and  
 ute, Adjustable and Differential Switches. The Bristol  
 any, Aircraft Components Division, 150 Bristol Road,  
 bury 20, Conn.

8.44



#### SPECIFICATIONS (Fixed pressure setting models)

**Normal Working Range**—0 to 100 psi absolute, gage, or differential

**Burst Pressure**—exceeds 250% of normal working pressure

**Electrical Ratings**—5 amp at 125 v, 60 cycle, inductive or resistive  
 4 amp at 30 vdc resistive  
 2.5 amp at 30 vdc inductive

**Dielectric Strength**—500 v rms between terminals and from terminals to case (MIL-S-8801)

**Life at Rated Electrical Load**—40,000 cycles at 125 vac  
 25,000 cycles at 28 vdc

**High Temperature Exposure & Operating**—(MIL-S-8801) 250° F

**Low Temperature Exposure & Operating**—(MIL-S-8801) -65° F

**Shock, 30 g, 3 axes**—(MIL-S-8801) no change

**Vibration**—(MIL-S-8801) no contact chatter, no switch damage

300-600 cpm at 0.050" d.a.—set point change—none  
 operating differential change—none  
 600-4500 cpm at 0.036" d.a.—set point change—1/4 psi  
 operating differential change—1/2 psi  
 4500-30,000 cpm at 10 g—set point change—1/4 psi  
 operating differential change—1/2 psi

**Diameter**—1-5/16

**BRISTOL** FINE PRECISION INSTRUMENTS  
 FOR OVER 69 YEARS

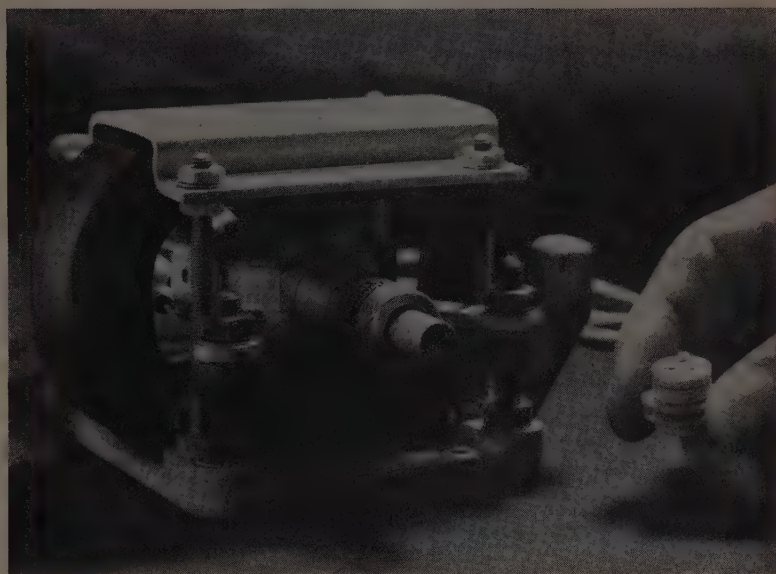
Circle No. 44 on Reader Service Card

January 1959

*space / aeronautics*

RESEARCH • DESIGN • DEVELOPMENT  
 aircraft / missiles / spacecraft

**product  
 of the month**



#### **PACKAGED MAGNETRONS** are pre-tuned and adjusted

General Electric Co., Schenectady 5, N. Y., has developed packaged S-band voltage-tunable magnetrons consisting of tube, magnet, cavity, and integrated parts. They are pre-tuned and adjusted.

Tuning characteristics are linear over a 1.7:1 frequency range or greater, with changes in anode voltage. Mechanical tuning is not necessary. Wide-band range is 2200-3850 mc, with a

minimum CW power output of two watts across the entire frequency range. GE engineers say no additional circuitry is needed to adapt the package for oscillator service, since it is a completely pre-assembled unit. Approximate outside measurements are 4x4x3 1/4 ft. GE is developing voltage-tunable magnetrons to cover 50 to 800 mc and over, with corresponding levels of power output.

Circle No. 108 on Reader Service Card in Product Review Section

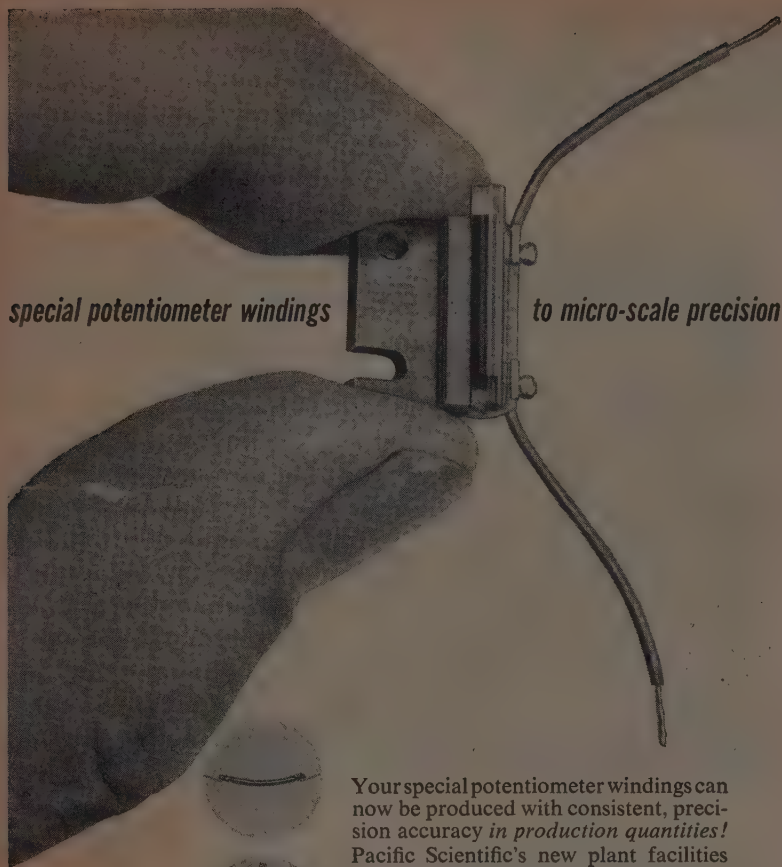


**JANUARY 1959**

*This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of aviation.*

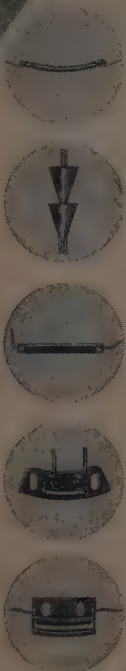
*Randolph Hawthorne*  
 Editor





special potentiometer windings

to micro-scale precision



Your special potentiometer windings can now be produced with consistent, precision accuracy in production quantities! Pacific Scientific's new plant facilities and specially designed microscopic winding equipment can now provide extremely close linearity tolerances on your special designs whether standard or sub-miniature, and in unusual configurations. Elements are wound to your own specifications on glass, Formvar-covered copper or aluminum mandrels, and X-Y recorder inspection assures uniformity of quality.

Pacific's engineering department can also help solve your special problems... and complete environmental facilities are available to test to the most rigid military specifications.

Call or write Pacific for engineering assistance on your special potentiometer problems—today!

#### complete potentiometers

Pacific also designs and builds complete potentiometers—both rotary and linear motion—to suit your requirements.

**PACIFIC SCIENTIFIC COMPANY**  
P.O. Box 22019, Los Angeles, California  
Gentlemen:

Please send me your new advance data folder giving engineering and design information on Pacific's special linear potentiometers.

Name \_\_\_\_\_  
Company \_\_\_\_\_  
Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_

**Pacific**

Circle No. 45 on Reader-Service Card in Product Review Section



#### PRESSURIZING WINDOW withstands 30 psi



A new pressurizing window, the BL 777, is announced by Bomac Laboratories, Inc., Dept. S/A, Salem Rd., Beverly, Mass. This Ku-band window has a maximum VSWR of 1.12 over a frequency range of 12.4 to 18.0 Kmc, and is for use in waveguide size RG 91/U.

The window is designed for mounting between UG 541/U choke flanges, can be pressurized to a maximum pressure differential of 30 psi, and will operate up to 100 kilowatts max.

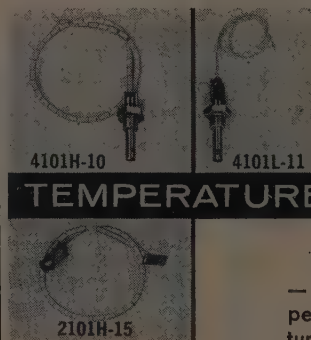
Circle No. 109 on Reader-Service Card

#### MAGNETIC AMPLIFIER is plug-in type

Acromag Model 410 magnetic amplifier for signal mixing and summing is a completely self-contained, plug-in magnetic amplifier and power supply weighing less than nine ounces. It is designed for missile guidance, analog controls, telemetering, and null-balance detectors. It operates directly from standard 115 V 400 cycle power, says Acromag, Inc., Dept. S/A, 22519 Telegraph Road, Detroit 41, Mich.

A unique feature of the new unit is that regulated power supplies, bias supplies, and external gain and balance controls are not required; the amplifier is inherently stable. Transimpedance,  $m$ , is 25,000 ohms; 100 microamperes/dc control current give 2.5 V/dc output; less than 10 microwatts of signal energy are required for full control; frequency response is dc to 50 cps depending on circuits used.

Circle No. 110 on Reader-Service Card



response:

**200 MSEC**

#### TEMPERATURE TRANSDUCERS

The newest line of Arnoux temperature transducer—100-ohm resistance, 200-millisecond response permits accurate measurement of transient temperatures such as those in missile and aircraft applications. The output signal is 0-5 vdc for as small a span as 180 F, when Arnoux transistorized TME-1 or TME-2 systems or similar equipment is used.

The fluid-immersion transducer (4101L-11), for static or moving fluid, is LOX compatible and available in two calibration ranges: -302 F to -285 F, -320 F to +500 F.

The air transducer (4101H-10) is for static to high velocity gases.

The surface transducer (2101H-15) is for material of limited area and thickness, and has great mounting versatility.

Both air and surface types are available in two calibration ranges: -100 F to +500 F, -100 F to +1200 F.

#### Other Specifications:

Calibration accuracy:  
0.1-1.0%, depending  
on temperature range

Repeatability and  
hysteresis:  
within calibration  
accuracy

Resistance at 32 F:  
100  $\pm$  5 ohms

Nominal temperature-  
resistance coefficient:  
0.0018/ $^{\circ}$ C

Output:  
0-5 vdc, when Arnoux  
100-ohm TME is used.



#### ARNOUX CORPORATION

11924 WEST WASHINGTON BLVD., LOS ANGELES 66, CALIF.  
Sales Offices: Beverly Hills, Calif. • Dallas • Great Neck, N.Y. • Seattle • Bryn Mawr, Pa.

Circle No. 46 on Reader-Service Card in Product Review Section  
SPACE/AERONAUTICS



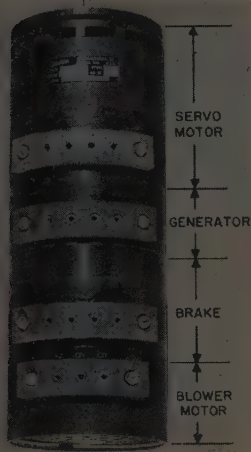
## WIREWOUND RESISTORS for printed circuits

Two miniature precision resistors are fixed non-inductively wire-wound types sealed in epoxy resin and suitable for operation in ambients up to 125 deg C. The P-2 resistor is  $\frac{27}{64}$  in long and  $\frac{13}{64}$  in diameter. Termination is by means of two #20 axial leads at one end of the resistor. Resistances up to 200,000 ohms may be supplied to tolerances as close as 0.1 per cent. The power rating for one per cent tolerance has been tentatively established at 0.3 W for 125 deg C ambient, says Shallcross Mfg. Co., Dept. S/A, Colngdale, Pa.

For higher resistance values the 10S resistor is recommended. Resistances up to one megohm may be supplied to tolerances as close as 0.1 per cent. The power rating for one per cent tolerance is 0.5 W for a 125 deg C ambient.

Circle No. 111 on Reader-Service Card

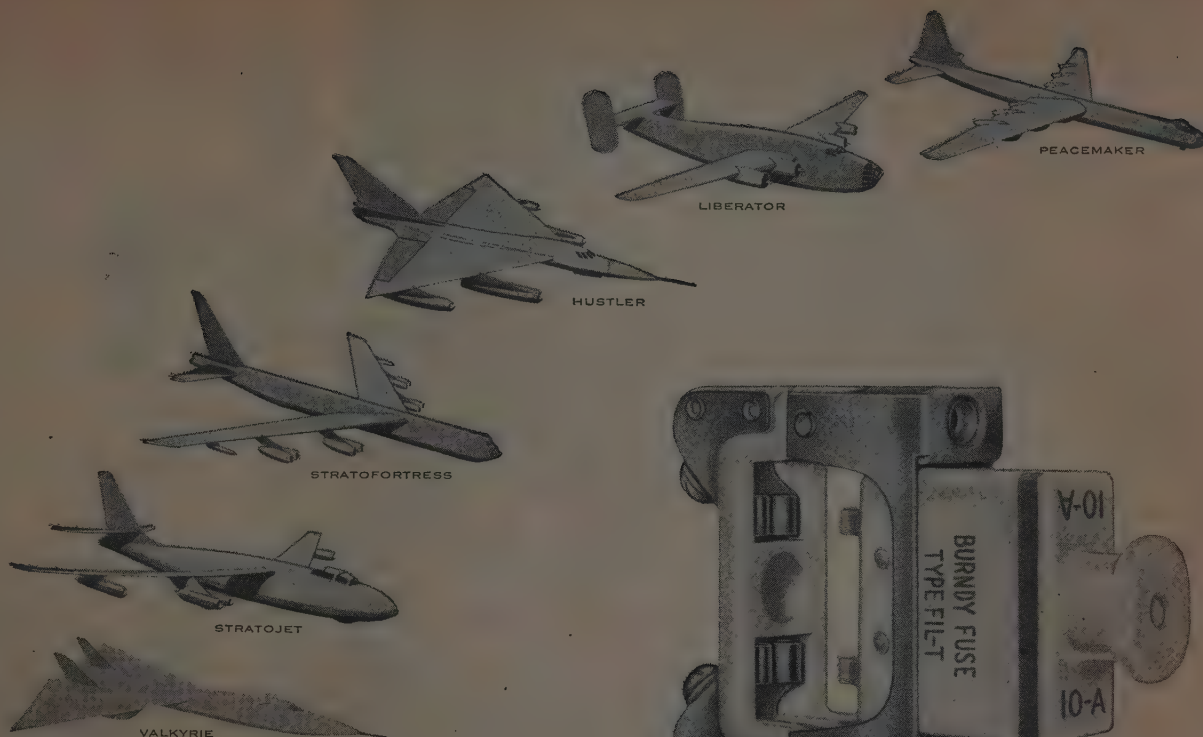
## ANTENNA DRIVER is multi-purpose device



A servomotor-generator, 28-V dc brake and cooling blower have been combined into a single unit, Type 23-MTG-6327-01, by John Oster Mfg. Co., Dept. S/A, Main St., Racine, Wisc. It is designed for driving antennas and other applications requiring self-cooled drive motors.

The servomotor is a 6000-rpm unit rated at 1/15 hp, and the generator has an output of 5 V per 1000 rpm, nominal, with linearity of  $\pm 2$  per cent up to 6000 rpm. The eight-in. unit is available in any desired combination of its components.

Circle No. 112 on Reader-Service Card  
more on next page



## THEN, NOW and TOMORROW—

for the toughest jobs in electrical circuit protection!

# BURNBY LIMITERS



Where reliability under extreme service conditions is imperative, airborne electrical systems are protected by Burnby LIMITERS. Here's why —

- Higher tripping temperature provides uniform, predictable performance in spite of ambient temperature variation...pinpoints the moment for protection.
- Inherently fail-safe. No mechanical parts.
- High interrupting capacity—in ratings from  $\frac{1}{4}$ A to 125A.

Indicating LIMITER (above) for dead front panel mounting, ambients up to 300°F, and visible indicating LIMITER (not shown) conform to MIL-F-5372B and MIL-F-5373B.

LIMITERS now in development for 600°F operation and nuclear applications.

OMATON DIVISION BURNBY NORWALK, CONNECT.; TORONTO, CANADA; IN EUROPE: ANTWERP, BELGIUM

Circle No. 47 on Reader Service Card in Product Review Section



# RUGGED



## GSE CONNECTORS

Connectors employed in Ground Support Equipment must be rugged and reliable—and easy to handle under any conditions. Fully meeting these particulars, AMPHENOL's popular 89 series GSE connectors are being used in many top missile projects.

GSE connectors are completely waterproof and provide dependable service even when submerged in mud, ice or water. An internal rubber gasket in the cable clamp, a type "W" washer at the mating faces and another washer used with panel mounting receptacles provide assured protection.

To facilitate handling in rough weather, coupling rings are extra-long and heavily grooved. Flats are conveniently located for field-servicing with standard open-end wrenches. Caps & chains are provided for all connectors.

AMPHENOL GSE connectors are available in a large number of standard "MS" inserts. Complete catalog data is available upon request.

AMPHENOL ELECTRONICS CORPORATION



chicago 50, illinois

## PRODUCT REVIEW

### BLADE ANTENNA for L-band



This new L-Band Canoga Model 9926 Blade Antenna is designed to operate in the 950 to 1250 megacycle band for use with communication and navigation equipment. This blade antenna provides an all-metal leading edge for maximum strength and erosion resistance. The high aspect ratio with straight or swept-back leading edge insures minimum drag, says Canoga Corp., Dept. S/A, 5955 Sepulveda Blvd., Van Nuys, Calif.

The polarization is perpendicular to the mounting surface and the resulting radiation pattern is circular. The Model 9926 has a maximum VSWR of 2.0 over its operating band, is 3.55 in. long, extends 1.70 in. from the skin of the airframe, and weighs 3 1/4 oz.

Circle No. 113 on Reader-Service Card

### CAPACITORS come flat and round

These new miniature Mylar dielectric capacitors, type XPR and XPF, are designed for use requiring minimum size, high insulation resistance and exceptional capacitance stability. A Mylar polyester outer wrap affords good protection against moisture, its ends being sealed with a plastic thermosetting resin. Voltage rating is 150 V at 85 deg C, 100 V at 125 deg C, says Astron Corp., Dept. S/A, 255 Grant Ave., E. Newark, N. J.

Reliable performance is had over the entire operating range of 135 to +125 deg C. The new series is available in flat and round construction.

Circle No. 115 on Reader-Service Card

### RECORDING SYSTEMS for six and eight channels



A completely new series of six and eight channel Direct Writing Oscillographic Recording Systems provide greatly reduced size, improved performance and greater reliability. The new 350 series are packaged in a single mobile vertical cabinet. Frequency response is flat to 100 cps at 10-division peak-to-peak amplitude and three decibels down at 120 cps. Linearity is within 0.2 div. over the entire 50 divisions. Hysteresis level is less than 0.2 div., says Industrial Div., Sanborn Co., Dept. S/A, 175 Wyman St., Waltham 54, Mass.

The rugged recorder features flush front recorder with paper take-up, transistorized plug-in amplifiers and power supply in 17 1/2 in. of panel space. A limiter ahead of the current feedback power amplifier prevents saturation or cutoff, hence damping is never lost.

Circle No. 116 on Reader-Service Card

### ABSORBER is permanent

This is a completely new Absorber, Type BL-48, for VHF, UHF and microwave ranges, for production and laboratory antenna testing, TV antenna test rooms or aircraft ramp testing of high-power-low-frequency radar. It is made of an inert plastic foam material and can be used for both indoor and outdoor applications. They maintain permanent attenuation characteristics with a frequency range from 40 mc to 35,000 mc, says McMillian Industrial Corp., Dept. S/A, Brownville Ave., Ispwich, Mass.

The absorber is supplied in wedge form, in blocks with a base of one by two feet and a height of four feet. The individual wedge block weighs five psf and has an average power reflection coefficient of 2 1/2 per cent at normal incidence.

Circle No. 114 on Reader-Service Card

Circle No. 48 on Reader Service Card



## POTENTIOMETER has high resolution

A completely enclosed, high resolution, two-inch-diameter potentiometer consists of a small diameter cylindrical Kohlrausch resistive element enclosed in a slim, piece housing molded of glass reinforced Alkyd, says DeJurco Corp., Dept. S/A, 45-01 Northern Blvd., Long Island City N. Y.

Series HP-200 can be supplied singly or as multiple ganged units. Mountings include pivoted servo or tapped holes. Power dissipation is three watts. Mechanical rotation is 360 deg. Up to 16 taps can be provided, depending on wiring. Precious metal brush, color and tap contacts, together with hard gold plated terminals and slip rings, are standard design features.

Circle No. 117 on Reader-Service Card

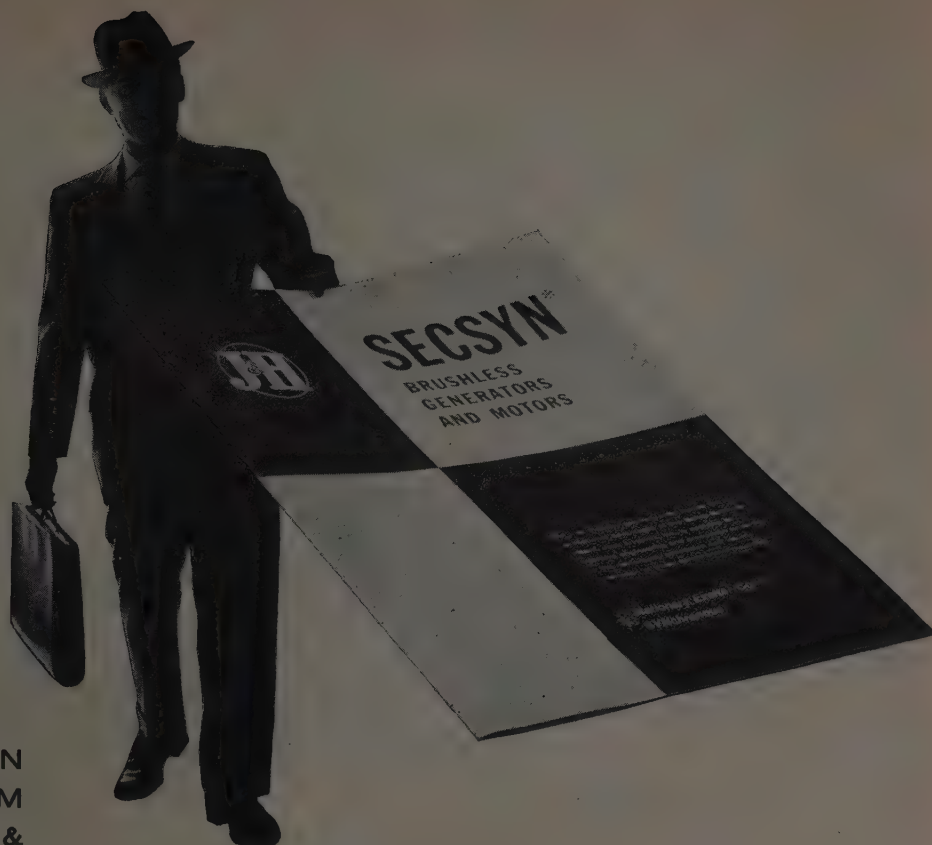
## RECORDER-TRANSCRIBER has 10 kc sampling rate



An electronic recording and transcribing system that can acquire and process data "at the phenomenal speeds needed in the space age" was introduced by Minneapolis Honeywell Regulator Co., Dept. S/A, Davies Labs, Beltsville, Md. Using magnetic tape, the new Digital Data Recorder-Transcriber can handle 100 channels of information at once on each of its 100 channels in measuring temperature, pressure, strain and other process variables.

The system has two main units. The recorder, located at or near the data source, absorbs information from electrical signals and converts them into digits on magnetic tape. The transcriber, an electronic playback, reproduces the original tape, selects and re-arranges pre-determined portions into block form for automatic processing in a computer and records the blocks of data on a final tape for direct computer entry. As many as 10,000 bits can be processed in eight minutes.

Circle No. 118 on Reader-Service Card  
more on page 112



THE MAN  
FROM  
JACK &  
HEINTZ  
INVITES  
YOU TO . . .

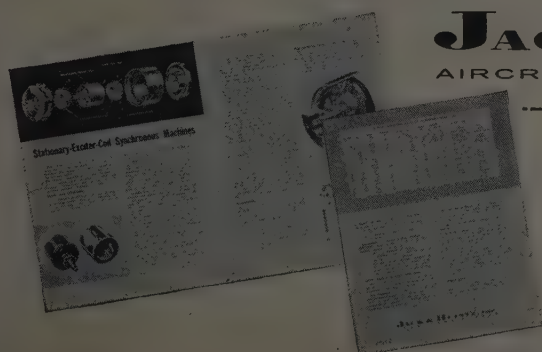
# Read about SECSYN

... Stationary-Exciter-Coil SYNchronous machines that run longer, faster, hotter and with less maintenance than any comparable-purpose machines now being used for ground support, missiles or aircraft.

This bulletin acquaints you with the design details of these unique machines whose unusual magnetic structure... *proved in use*... eliminates brushes, rotating windings, rotating rectifiers and other elements that impose limitations on conventional machines.

The SECSYN design can be used as a-c generator, d-c generator, synchronous motor, constant-speed motor, or as a synchro. In all applications, the design offers improvements in size, weight, operating speeds, operating temperatures, service life and maintenance.

SECSYN can be the answer to your most pressing design problem. Send today for this bulletin... the Man from Jack & Heintz is available to answer any questions concerning your specific application.



**JACK & HEINTZ, Inc.**  
AIRCRAFT SYSTEMS AND EQUIPMENT

Jack & Heintz, Inc., 17634 Broadway, Cleveland 1, Ohio  
Please send me your bulletin on the SECSYN Brushless Machines.

NAME AND TITLE \_\_\_\_\_

COMPANY \_\_\_\_\_

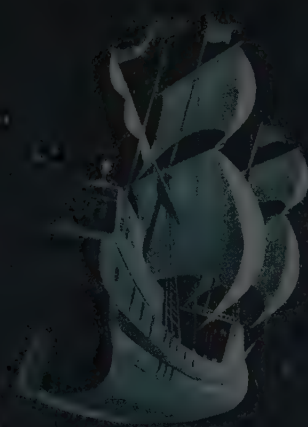
ADDRESS \_\_\_\_\_

CITY AND STATE \_\_\_\_\_

Circle No. 49 on Reader Service Card in Product Review Section



# SOLAR SAILING



EXPANDING THE FRONTIERS OF SPACE





**SOLAR SAILING:** Space travel with the aid of solar radiation pressure—an area of advanced research at Lockheed. Vehicle would employ a sail that would be raised and lowered in flight. The artist has depicted Magellan's ship "Trinidad" to symbolize man's great voyages of discovery.

**Lockheed Missile Systems Division** is engaged in all fields of missile and space technology—from concept to operation.

Advanced research and development programs include—man in space; space communications; electronics; ionic propulsion; nuclear and solar propulsion; magnetohydrodynamics; computer development; oceanography; flight sciences; materials and processes; human engineering; electromagnetic wave propagation and radiation; and operations research and analysis.

The successful completion of programs such as these not only encompasses the sum of man's knowledge in many fields, but requires a bold and imaginative approach in areas where only theory now exists.

The Missile Systems Division programs reach far into the future.

It is a rewarding future which men of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. A-16, 962 W. El Camino Real, Sunnyvale, California.

*"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics."*

NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

**Lockheed** / **MISSILE SYSTEMS DIVISION**

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA  
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO

CHNOLOGY





## TELEFLIGHT<sup>®</sup> NEW MODEL 180 AIRBORNE PRESSURE TRANSDUCER



One of the first and most satisfactory of all Pressure Transducers, the Taber Teleflight has now been reengineered to a weight of LESS than 10 ozs. Its BONDED STRAIN GAGE construction makes it almost completely insensitive to vibration and shock. Its INFINITE RESOLUTION makes possible measurement of feather-light pressures.

Can be used with Taber Indicator (shown below) or standard recorders and controllers to measure liquid or gaseous pressures. Handles extremely corrosive media, including fuming NITRIC ACID. Pressure ranges: 0-750 or 0-1,000 PSIA or PSIG with overload of 100%, Linearity 0.3%, Hysteresis 0.25% of F.S. at any given point, Ambient Temperature -65° F. to +250° F. (18° C to 121° C).

For ground testing, the Teledyne Models 176, 206 and 217 with pressure ranges from 0-100 up to 0-10,000 PSIG have long been favored by rocket and missile men.

WRITE FOR LITERATURE

### TABER INSTRUMENT CORPORATION

Section 36 107 Goundry St., North Tonawanda, N. Y.  
Telephone: LUDlow 8900 TWX - TON 277

Circle No. 81 on Reader Service Card in Product Review Section

## PRODUCT REVIEW

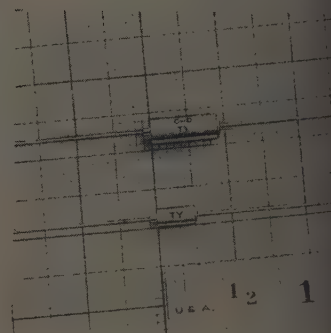
### LINEAR AMPLIFIER for low signal levels

Model 672A, AID Linear Amplifier is built to ORNL Spec. Q1326. It amplifies pulses of low signal level from radiation detectors such as ionization chambers, proportional counters and scintillation counters to usable levels that can function in counting systems such as scalars, ratemeters and pulse height analyzers, says Victoreen Instrument Co., Dept. S/A, 5806 Hough Ave., Cleveland 3, Ohio.

Input sensitivity is from 200 microvolts to one mv. Gain, depending on bandwidth switch position, is 12,000 with switch set at 0.1 mc; 6000 at 0.5 mc; and 2000 at 2.0 mc (delay line). Output at high amplifier output is five V into 1000 ohms; at low amplifier output, five V into 150 ohms. Linearity is better than one per cent from nine to 90 V output; stability better than one per cent after 24-hour warm-up.

Circle No. 119 on Reader-Service Card

### CAPACITORS have tantalum film



A series of solid electrolyte capacitors, Solitan, designed for transistor application in computer and military circuits contain absolutely no liquid electrolyte, residue or moisture of any kind. Tantalum oxide film on the anode is the means for producing this solid-state capacitor, says Cornell-Dubilier Electric Corp., Dept. S/A, So. Plainfield, N. J.

Advantages of these capacitors are: considerably smaller sizes due to better space-saving factors; temperature range -80 to +85 deg C; better stability of capacitance with time and temperature; freedom from corrosion and effects of vibration; freedom from deteriorating effects of extended shelf-life and service aging.

Circle No. 120 on Reader-Service Card  
more on page 115

## THIN VERSATILE DUCTILE NETIC CO-NETIC FOIL

Aids Miniaturization & Reliability... Cuts to Any Shape with Scissors... Wraps like Tape... Shields Both High & Low Frequencies at Low Intensities

One or more layers are readily applied and their effects observed, permitting engineer to determine optimum location and number of layers needed for adequate shielding. Can be trimmed to any dimension or outline with ordinary scissors. Easily formed by hand. Dead soft; does not spring back into original position after forming. Aids miniaturization by reducing shielding bulk and by making possible crowding components closely together.

15" wide Co-Netic foil is non-shock sensitive, non-retentive, does not require periodic annealing and attenuates low level fields. When used with 193" wide Netic foil, higher ratios of attenuation for relatively intense fields are achieved. Both foils are immediately available from stock in .004" thickness in continuous rolls up to any length desired.

These versatile light weight time-saving foils open up a whole new shielding concept in laboratory, air borne, electronic, electrical and shielded room applications. Write for complete details today.

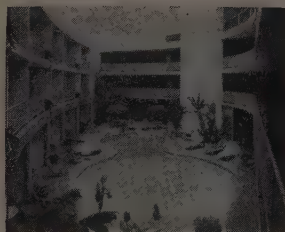


### MAGNETIC SHIELD DIVISION PERFECTION MICA COMPANY

1322 No. Elston Avenue, Chicago 22, Illinois  
Originators of Permanently Effective Netic Co-Netic Magnetic Shielding

Circle No. 82 on Reader-Service Card

## Convenient to the Los Angeles Aviation and Electronics Industry



### BEVERLY CARLTON HOTEL

9400 W. Olympic Blvd.  
Beverly Hills, Calif.

Tarif: \$8 to \$13 Sgl.  
Double slightly higher



### CAVALIER HOTEL

10724 Wilshire Blvd.  
West Los Angeles, Calif.

Tarif: \$8 to \$16 Sgl.  
Double slightly higher

### Both Hotels Feature

- ★ Beautiful heated pool
- ★ TV in every room
- ★ Complimentary Breakfast
- ★ No charge for parking

### WRITE FOR COLOR BROCHURES

OTHER LEE HOTELS  
SKYWAYS HOTEL, L. A. AIRPORT  
HOLLYWOOD-PLAZA HOTEL, HOLLYWOOD  
HOTEL LAGUNA, LAGUNA BEACH  
Bellevue Hotel, San Francisco • Flamingo Hotel, Phoenix

Circle No. 83 on Reader-Service Card



RADAR  
BEACONS



*advanced-  
technique  
avionics*



NAVIGATION DISPLAY SYSTEMS



INFRARED GUIDANCE • CONTROL • DETECTION

**AVION**  
acf

**acf INDUSTRIES**  
INCORPORATED

**AVION DIVISION**

MILITARY • INDUSTRIAL

Equipment and Components • 11 Park Place, Paramus, N.Y.

ACF DIVISIONS: AMERICAN CAR AND FOUNDRY, AVION, NUCLEAR  
PRODUCTS-ERCO, CARTER CARBURETOR, SHIPPERS CAR LINE, W.K.M.

**AVION**

FOREMOST IN AVIONICS



POWER SUPPLIES  
Magnetic • Transistorized



MICROWAVE COMPONENTS  
S-Band, C-Band, X-Band



SERVO AMPLIFIERS  
fast response



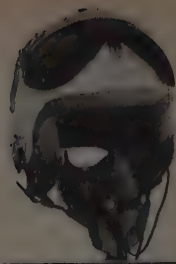
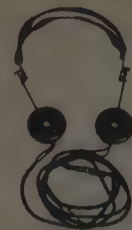
MAGNETIC COMPONENTS  
Performance Qualified



DATA PROCESSING  
Encoders • Decoders

Circle No. 84 on  
Reader Service Card  
in Product Review  
Section



**A****B****C****D****E****F****G****H****I****J****K****L**

## Working headgear for Motorola design engineers

From the arctic to the tropics...from jet altitudes to submarine depths...Motorola design engineers wear headgear matching the varied military applications of Motorola electronics. Working side-by-side with the Army, Navy and Air Force end user, these engineers provide technical assistance and, in return, gain first hand operational knowledge. The result—an understanding of user problems reflected in the design maturity of Motorola's military electronics systems.

And as for the many hats, those shown above have been worn on these representative programs: **A** Integrated Battlefield Communication **B** Supersonic Rendezvous and Station Keeping **C** High-speed Tank Range Finder **D** Test Range Microwave Relay System **E** Ballistic Missile Radio Inertial Guidance System **F** Shipboard Surface-to-air Missile Guidance **G** Member, Army Scientific Advisory Panel **H** DEW Line Air Defense Radar **I** Strategic Bombing Radars **J** Amphibious Landing System **K** Shipboard Air Defense Data System **L** Tactical Drone Guidance. For data on how Motorola's military experience can be applied to your problem...or for detailed information on engineering career opportunities...write to: Motorola, Inc., Military Electronics Division, Dept. A, 8201 East McDowell Road, Phoenix, Arizona.

**MOTOROLA**

**Military Electronics Division** CHICAGO • PHOENIX • RIVERSIDE





CHICAGO



PHOENIX



RIVERSIDE



Working  
laboratories  
for Motorola  
engineers

Six Military Electronics Division plants in three locations...over 550,000 square feet of engineering and production space devoted exclusively to the design, development and manufacture of advanced military equipment.



**MOTOROLA**

Military Electronics Division

Circle No. 85 on Reader Service Card or send personal resume direct to the address. GIVE HOME ADDRESS.

## PRODUCT REVIEW

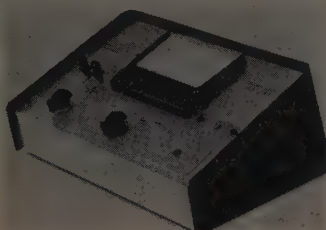
### DATA CONVERTERS are flexible

Reversible analog-to-digital and digital-to-analog converters, and alarm limit monitors are included in a line of data converters that is based on assembly of a number of modular units. Over 50 standard models can be assembled from the basic plug-in building blocks, says Epsco, Inc., Dept. S/A., 588 Commonwealth Ave., Boston 15, Mass.

The transistorized Transicon Datrac, require no adjustments and use high-power outputs to drive external circuits directly. The units are designed for expansion, and eight-bit converters can be increased to ten, 12 or 14 bits. Codes may be changed from binary to binary coded decimal. The analog-to-digital Datrac can provide up to 25,000 conversions per sec, and the digital-to-analog unit handles up to 100,000 conversions per sec. Alarm limit monitors have a conversion rate of 200,000 conversions per sec.

Circle No. 121 on Reader-Service Card

### COMPACT TESTER measures beta, ico, ibco



An accurate system that determines the basic parameters of a transistor has been designed into this new unit. Beta and Ico are examined as well as the Figure of Merit of a transistor, Ibco. The test set accurately measures Beta, Ico and Ibco of both PNP and NPN type transistors at any desired operating level. Component matching accuracy of about two per cent is provided. Simplicity of the control panel and test procedure makes the tester compatible with the requirements of high rate quality control testing, says Armour Electronics, Inc., Dept. S/A, 10800 Ventura Blvd., Studio City, Calif.

Modern circuit techniques are used throughout the unit which weighs only 4 1/4 lb and is enclosed in a cabinet five inches high, 11 in. wide and nine inches deep. All electrical power is derived from four mercury cells.

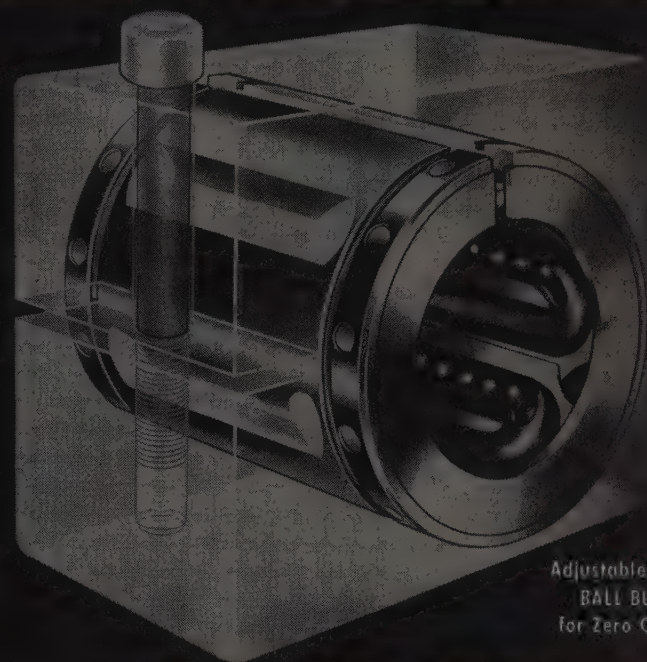
Circle No. 122 on Reader-Service Card  
more on next page

Circle No. 86 on Reader Service

**NOW!**

Adjustable Diameter and Open  
**THOMSON**

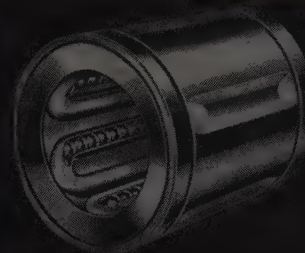
# BALL BUSHINGS



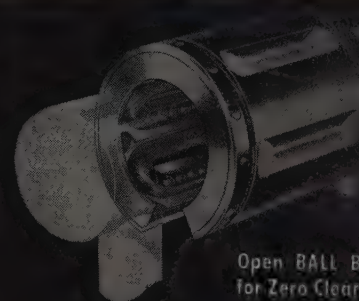
Adjustable Diameter  
BALL BUSHING  
for Zero Clearance

The BALL Bearing  
for all your

## LINEAR MOTIONS



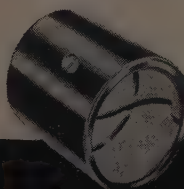
Precision Series "A" and  
Low Cost Series "B" BALL BUSHING



Open BALL BUSHING  
for Zero Clearance on  
Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!



**LOW FRICTION • ZERO SHAKE OR PLAT  
ELIMINATE BINDING AND CHATTER  
SOLVE SLIDING LUBRICATION PROBLEM  
LONG LIFE • LASTING ALIGNMENT**

The various types cover a shaft diameter range of 1/8" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

**THOMSON INDUSTRIES, Inc.**

Dept. D, MANHASSET, NEW YORK

Also Manufacturers of NYLINED Bearings, Sleeve Bearings

of DuPont Nylon and 60 CASE Hardened and Ground Steel Shafting





FROM AN ORIGINAL PAINTING FOR CECO BY R. T. HANDVILLE

## Contributing to superb performance

The Bell H-40, newest Army Utility Helicopter, is powered by a Lycoming T-53 gas turbine engine with *complete unitized fuel control system* engineered and built by Chandler-Evans.

Products, too, are "known by the company they keep", and CECO is proud to be airborne with many of the latest and finest military and commercial aircraft.



**CHANDLER-EVANS**  
WEST HARTFORD 1, CONNECTICUT



CECO's Model TA-1, a complete unitized fuel control system, is shown in position on cutaway model of Lycoming's T-53 gas turbine engine. It incorporates a dual-element main fuel supply pump, free power turbine governor, automatic altitude and temperature compensation, and integral emergency fuel metering system.

*Interesting, informative literature on many CECO products is yours for the asking. Please address your request to Department 18.*

Circle No. 93 on Reader Service Card in Product Review Section

## PRODUCT REVIEW

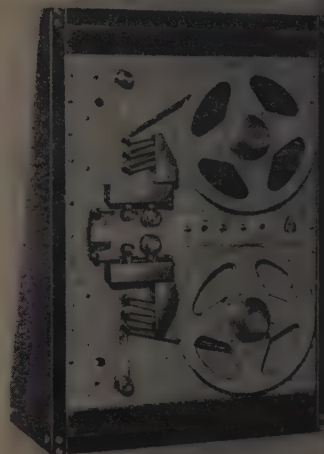
### TRANSISTORS are 60 and 100 V

Two new diffused-base silicon medium power transistors feature four-watts at 25 deg C case temperature and one watt at 150 deg C case temperature dissipation ratings. Both new N-P-N transistors feature a typical saturation resistance of 20 ohms at 25 deg C plus an operating range of -65 deg to +200 deg C and are temperature stabilized at 215 deg C, says Texas Instruments, Inc. Dept. S/A, P. O. Box 312, Dallas, Texas.

The 2N497 is a 60 V transistor for use with the 28 V power supplies employed in military aircraft. The 2N498 is a 100 V device for use in higher voltage applications such as servo amplifiers and regulated power supplies for missile applications.

Circle No. 123 on Reader-Service Card

### TAPE HANDLER for digital computers



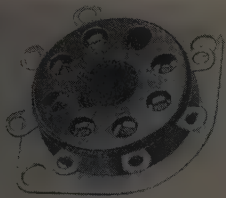
Increased tape speed of 75 ips and 40 start-stop cps in the new Model 101 digital magnetic tape handler comes in as few as six and as many as 20 tracks. Choice of tape speeds range from two to 75 ips. Complete remote control of start, stop, reverse and speed change functions is furnished as well as single or dual tape speeds as required, says Digitronics Corp., Dept. S/A, Albertson Ave., Albertson, N.Y.

Two solenoids start the tape in less than five milliseconds. Equally fast stops are obtained by dual braking solenoids that press the tape against stationary capstans as it is released from the driving capstans. On a 19 in RTMA standard relay rack it uses 24½ in and a 9 in depth.

Circle No. 124 on Reader-Service Card



**KLYSTRON SOCKET**  
saves assembly time



Assembly time is said to be reduced and rework eliminated by the use of a new moulded chassis mounted octal socket for the JAN-2 RP-2 K45 thermally tuned klystron tube. Self-aligning gold plated contacts are flexibly mounted in slightly over size orifices of a glass filled diallyl phthalate socket body. The new socket provides accurate alignment and probe penetration in the wave guide mount which avoids any possibility of mismatch, says Globe Electrical Mfg. Co., Dept. S/A, 1729 W. 134th St., Gardena, Calif.

Design of the socket eliminates the need for insulated bushings and any contact shorting to the wave guide tube mount. Contact tabs are easily accessible for fast accurate circuit assembly.

Circle No. 125 on Reader-Service Card

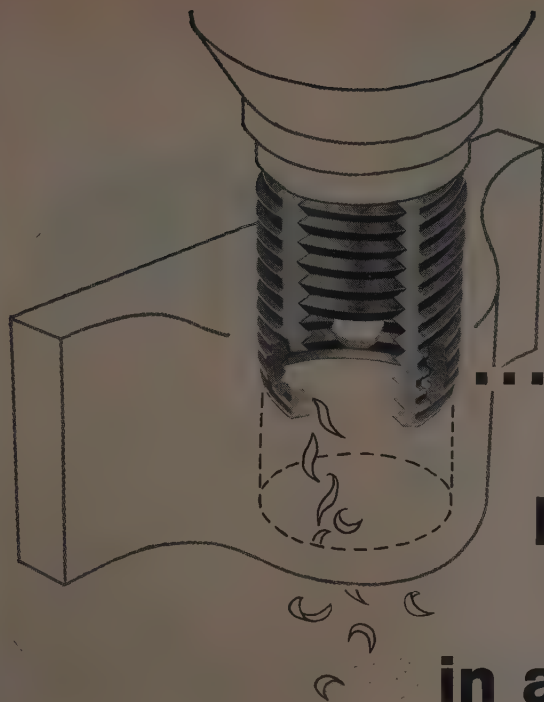
**POWER SUPPLY**  
is transistorized

This REL-203 Power Supply is a completely solid-stat unit employing the latest techniques of transistor switching to attain high efficiency and reliability, says Rheem Mfg. Co., Electronics Div., Dept. S/A, 7777 Industry Ave., Rivera, Calif. An r-f Filter is included in the 28 V input to prevent interference being conducted to radio equipment. The typical r-f voltage level is down 50 db at 14 kc and down 80 db at 150 dc.

The unit weighs two lb. It has an input voltage of 24 to 30 V dc, an input current of 0.2 to 3.2 amps dc depending on load. Maximum power output is 80 W. (no heat sink -75 to +158 deg F.) Efficiency at full load is 88 per cent.

Circle No. 126 on Reader-Service Card

more on next page



**...taps its own thread**  
**locks itself in...**  
**in a**  
**single operation!**

# The TAP-LOK<sup>®</sup>

## threaded insert



TAP-LOK inserts provide strong wear-resistant threads in relatively soft machinable materials (wood, plastic, aluminum, etc.) ... as well as in *harder* materials where repeated assembly makes excessive thread wear a problem.

Unlike ordinary threaded inserts, however, TAP-LOK inserts cut their own threads in the parent material. Thus, *no additional assembly time is required* with a TAP-LOK insert.

Its installed cost is the lowest of any threaded insert.

The locking action is achieved in this way: the tapered pilot section carrying the thread cutting edges is followed by the full diameter threads which force their way into the parent material. Once installed, a TAP-LOK insert is permanently locked in place.

Available in the types shown below, TAP-LOK inserts can be used wherever threaded inserts are required. Write today for complete information.



**Slotted:**—Full V-form external threads provide maximum locking torque; permit wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings, plastics. Class 2B internal thread — MIL-MS 35914.



**H-Series:**—A heavy wall insert with truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.



**W-Series:**—Coarse-pitch external thread offers maximum strength; permits installation in small wooden sections without splitting. For furniture, cabinets and other wooden parts where strong, permanent threads are required.



**P-Series:**—This Tap-Lok insert was designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. It is available from stock for standard plug sizes to meet most needs.

# TAP-LOK



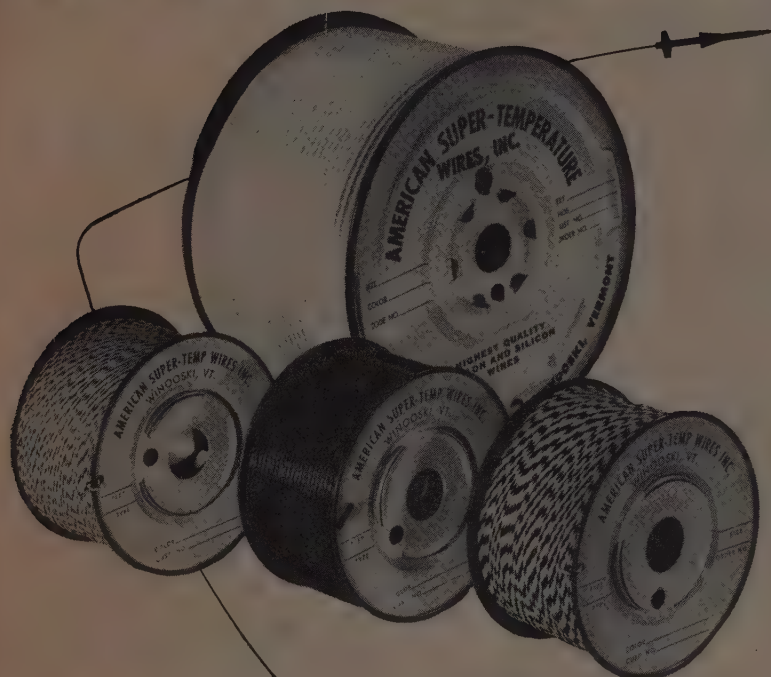
Another fastener development from —  
**GROOV-PIN CORPORATION**

1121 Hendricks Causeway, Ridgefield, N. J.

Circle No. 96 on Reader Service Card in Product Review Section



# High Temperature WIRES *and* CABLES



## Save Time WITH Super-Temp

MAGNET WIRE  
LEAD WIRE  
MINIATURE CABLES  
JUMBO CABLES  
LACING CORDS  
TUBING  
SPECIALTY WIRE  
TEFLON TAPES

*Fastest delivery . . . highest quality . . . optimum reliability . . . these are the qualities that make Super-Temp's TEFLON\* insulated, high temperature wires first choice all the time. Super-Temp has the right wire, cable or tubing, designed for specific applications, or can fabricate them to your particular requirement.*

**NEED IT FAST? . . . SEE SUPER-TEMP FIRST!**

**FREE!**

Send For  
Valuable  
NEW 64  
Page  
Catalog



## Super-Temp

**American Super-Temperature Wires, Inc.**

16 West Canal Street, Winooski, Vermont • University 2-9636  
General Sales Office: 195 Nassau St. • Princeton, N. J. • Walnut 4-4450

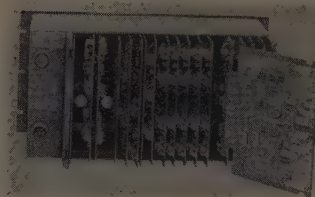
Agents in principal electronic manufacturing areas

\*DuPont's TFE Resin

Circle No. 87 on Reader Service Card in Product Review Section

### PRODUCT REVIEW

#### CONVERTER for analog to digital

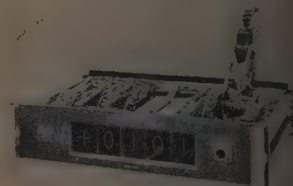


This new type 525 Encoder (analog to digital converter) is an all-electronic converter providing precise and dependable conversion of analog input data to digital output voltages. It makes possible the use of versatile, noise-free digital transmission and computing techniques to a greater degree of accuracy than heretofore possible, says Avion Div., ACF Industries, Inc., Dept. S/A, 800 No. Pitt St., Alexandria, Va.

When used in combination with an Avion Model 1002 Decoder, it is possible to solve problems in telemetering analog computation, digital computation, PCM, and many other data processing applications.

Circle No. 127 on Reader-Service Card

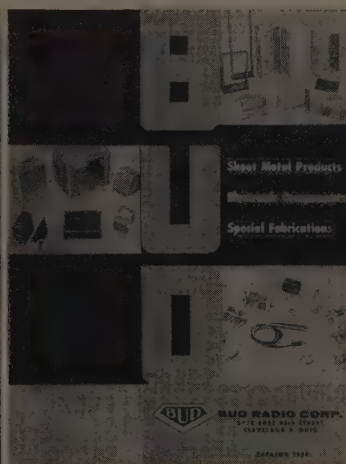
#### DIGITAL SYSTEMS are all-transistorized



This all-transistorized Digital Systems, include a digital voltmeter, control unit, ratiometer, ohmmeter, ac converter, master scanner and printer units. The voltmeter features polarity symbols, decimal point and ac symbol. Bridge linearity is greater than 0.01 per cent and bridge resistance is 50 K ohms, says Cubic Corp., Dept. S/A, San Diego, Calif.

Automatic features include polarity and voltage ranges. Accuracy is greater than 0.01 per cent. Input terminals are supplied at either the front panel or the rear connector panel. All units are of standard size; 17 in. wide, 3 1/2 in. high and 11 1/2 in. deep.

Circle No. 128 on Reader-Service Card



# free...

YOUR SPECIFYING and  
BUYING GUIDE of

**SHEET METAL  
PRODUCTS  
ELECTRONIC COMPONENTS  
SPECIAL FABRICATION**

**ILLUSTRATING AND DESCRIBING THE  
MOST COMPLETE LINE OF . . .**

**Enclosures • Condensers • Cabinets • Chassis •  
Chokes • Panels • Racks • Coils • Boxes • Cases**

Your designing, specifying and ordering will be quicker and easier with this new Bud Catalog. Get your personal copy now from your Bud Distributor or write direct to us and we will instruct your distributor to send one to you.



**BUD RADIO CORPORATION**

2118 East 55th Street, Dept. A  
Cleveland 3, Ohio

Circle No. 88 on Reader Service Card in Product Review Section

SPACE/AERONAUTICS



## INFRARED DOME made in one piece



Domes useful in transmitting infrared radiation to detection equipment are being produced in one piece, according to Servo Corp. of America, Dept. S/A, 10-20 Jericho Turnpike, New Hyde Park, N.Y. The Servofrax domes, which are made of arsenic sulphide glass, can withstand high acceleration and subzero temperatures.

Their negative lens effect can sometimes be used effectively as a Maksutov corrector for concentric optical systems. The domes are available in diameters from four to 12 in and in any spherical section up to and including 180 deg.

Circle No. 129 on Reader-Service Card

## POTENTIOMETER has 2% resolution



A new 0.6 W wirewound miniature precision potentiometer, Model DM, is one-half inch in diameter, 0.1 ounce in weight, and is available in stock values from 10 ohms to 50K ohms and features a resolution of 0.2 per cent, says B-H Electronics, Dept. S/A, P.O. Box 25124, Los Angeles 25, Calif.

The unit requires no mounting hardware and mounts directly to chassis or printed circuit either manually or by machine. Tinned leads (0.032 diameter) are E.I.A. modular spaced. Shock tested to 100G, three planes. No electrical noise under 25G, three planes. Other features include 320 deg rotation, range from -55 to +150 deg C and retention of setting during vibration and shock.

Circle No. 130 on Reader-Service Card

more on next page

## Airborne Miniaturized Mylar\* Capacitors help reduce weight and bulk in electronic packages



Amplifier for oil temperature servo control system utilizes Airborne miniaturized "Mylar" capacitors to save weight and insure high reliability. Entire system, including rotary actuator, is Airborne produced and is designed to meet specifications MIL-E-5272A, MIL-E-5400A, etc. Environmental requirements include -65 to +200°F. and up to 60,000 ft. altitude.

Developed originally for motor start and run purposes, Airborne miniaturized "Mylar" capacitors are currently finding increasing application in electronic circuits where small size, light weight, and high reliability are of paramount importance.

Typical of such applications is one of our own servo control amplifiers, shown above. Used as a component of an Airborne-designed oil temperature control system for high performance aircraft, the amplifier consists of a .1% precision resistance bridge, stable feedback transistor amplifier, reference oscillator, phase demodulator, and relay output amplifier. Production units employ printed circuitry.

Two of Airborne's miniaturized

"Mylar" capacitors are utilized in this particular amplifier — a .1 mfd unit for tuning in the reference oscillator section of the amplifier and a .02 mfd unit for phase shift correction in the stable feedback transistor amplifier section. Capacitors are epoxy encased and are designed to meet or exceed Government specification MIL-C-25A.

Wound of thin metallized "Mylar" film, Airborne miniaturized capacitors are rated up to 600 v d-c, 330 v a-c and have an operating temperature range of -75 to +300°F. At 300°F they will withstand 120% rated voltage for 250 hr.

Write, phone or wire for more information on Airborne special design miniaturized "Mylar" capaci-

tors. Inquiries are also invited on complete electromechanical control systems.

\*Du Pont's trademark for its polyester film

### TYPICAL SPECIAL CAPACITORS



E-8109 Style

E-8104 Style

E-8107 Style

### CATALOG 57B

Gives detailed information on Airborne special design miniaturized "Mylar" capacitors and Airborne R.F. filters. Write for copy.



LINEATOR® • ROTORAC® • TRIM TROL® • ROTORETTE® • ANGLgear® • ROTOLOK



**AIRBORNE ACCESSORIES CORPORATION**

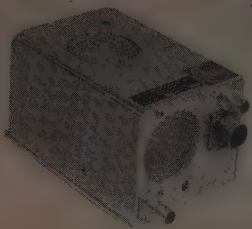
HILLSIDE 5, NEW JERSEY

Represented in Canada by: WINNETT BOYD LIMITED • 745 Mt. Pleasant Rd., Toronto 12, Ont.

Circle No. 91 on Reader Service Card in Product Review Section



**POWER AMPLIFIER**  
features high gain

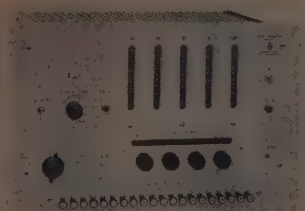


The Model REL-10 power amplifier, which can be used with most FM transmitters, delivers from ten to 100 W of r-f with two W of drive, says Rheem Mfg. Co., Dept. S/A, 777 Industry Ave., Rivera, Calif. The  $5\frac{1}{2} \times 3\frac{1}{2} \times 3$ -in. unit boosts signal power significantly in the 215 to 260-mc telemetering band.

It is very reliable in adverse environments of shock, vibration, and temperature, and it has a self-contained cooling system. It is suitable for missile-borne instrumentation systems.

Circle No. 131 on Reader-Service Card

**COUNTERS**  
for FM/FM telemetering



Simplified telemetering measurements that combine high resolution and short measurement time may be made with Model 2503 FM/FM Telemetering Counters. Channels are push-button selected and the visually displayed count is normalized to read deviation from midband directly in per cent of the midband period. A resolution by one part in  $10^5$  is achieved with a one-second measurement period. The period can be reduced by front panel control to 0.1 sec, says Dynac, Inc., Dept. S/A, 395 Page Mill Rd., Palo Alto, Calif.

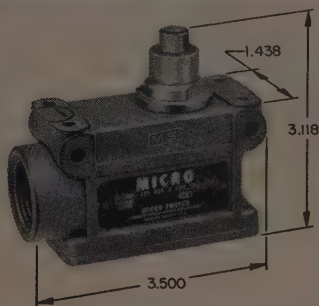
The unit has five decimal places and uses an internal crystal-controlled 100 kc time base or an external time base. It also measures frequency and ratio either directly or normalized. Two models, one for field and one for laboratory, are available.

Circle No. 132 on Reader-Service Card

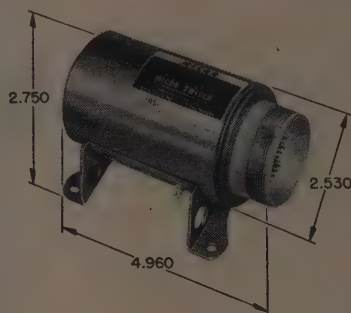


# MICRO SWITCH Precision

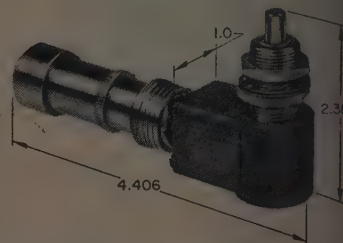
**These 17 switches represent the widest for aircraft, missile, rocket, launcher,**



**4CE1**—This weather-proof, corrosion-resistant switch is used as an indicator or limit switch on missile shelter, erecting and launching equipment. Has SPDT contact arrangement. Rating: 10a. 125vac; 5a. 250 vac. Operating force 6-10 lbs. Data sheet 151.



**1RS1**—High reliability telemetering switch for missile program sequencing. Hermetically sealed. Has rotary solenoid and 24 SPDT gold-contact "SM" switches. 74 terminals. Quick disconnect plug. Data sheet 151.



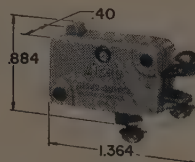
**1EN42-R**—A special design for high shock applications. Used on shipboard launching equipment. Meets requirements of U. S. Navy Bureau of Ordnance. Contains two SPDT switches. Quick disconnect connector. Ice and mud scraper on plunger. Operating force 6-12 lbs. Rating at 28vdc: inrush 24a., resistive 4a., inductive 3a., motor 4a. Data sheet 151.



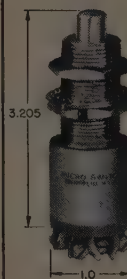
**54PB67-T2**—Space-saving lighted pushbutton assembly. Flexible indication provided by indicator lamp and two-level position of button. Alternate action (on-off) of the switch contacts is provided. Four SPDT subminiature switches. All switch and lamp terminals are isolated. Data sheet 133.



**1SE1**—Smallest sealed environment-free switch. SPDT. Rating at 28vdc: ind. 3a., res. 4a., inrush 15a. Leaf and roller-leaf auxiliary actuators available. Catalog 77.



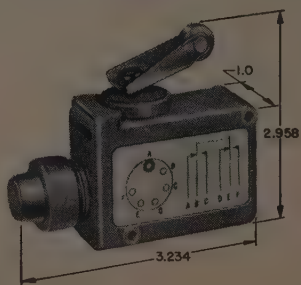
**V3-1301**—Operates reliably at 600°F. For jets, missiles, electronic gear. SPDT. 30vdc rating: ind. 10a., res. 10a., motor 6a. Cat. 74.



**12HR1-S**—Hermetically sealed, high temperature DPDT switch for reliable use to 600°F. All seals in accordance with Par. 5.2.2, MIL-E-5272A. Ice scraper ring on actuator. Rating: 28vdc—res. 5a.; ind. 2a. Operating force 6-12 lbs. Data sheet 122.



**44EN1-6 (MS-24420-4)**—Rotary actuator adjustable through 360°. One 4-circuit basic switch. Rating: 28vdc—inrush 30a.; res. 15a.; ind. 10a. Operating torque—10 in. lbs. Catalog 77.



**3EP2-E**—Sealed enclosure. Rugged, two-hole side mounting. Two high capacity SPDT basic switches. Sealed connector receptacle and roller lever actuator. Rating: 28vdc—inrush 36a.; res. 10a.; ind. 6a. Operating force 4-6 lbs. Catalog 77.

**201LS1**—Heavy duty, sealed "Plug-in Limit" switch. Can be replaced on the job in 20 seconds. Switch enclosure, with actuator, positioned by dowels and secured by two No. 10 screws. Available in six actuator designs. Used in ground equipment as limit or indicator switch. Catalog 84.





# Switches have uses unlimited



## Range of precision switches available marine and ordnance applications

Each of the switches illustrated on these pages represents a different series of MICRO SWITCH Precision Switches . . . Each switch has been designed to high reliability standards for a particular purpose . . . Each series includes many variations—sizes, weights, contact arrangements, electrical characteristics, housings, actuators, sealing, temperature, shock and mechanical characteristics . . . For example, the switches in which "EN" is a part of the catalog listing constitute a series in which nearly 100 different switches and assemblies are available . . . No other source of precision switches offers as broad a line . . . Furthermore, no other can offer the services of as large a staff of Application Engineers—in branch offices at strategic points throughout the country. Consult the yellow pages.

MICRO SWITCH . . . FREEPORT, ILLINOIS  
A division of Honeywell

In Canada: Honeywell Controls, Ltd., Toronto 17, Ontario

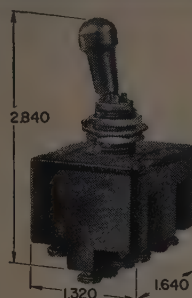


# Honeywell

MICRO SWITCH PRECISION SWITCHES

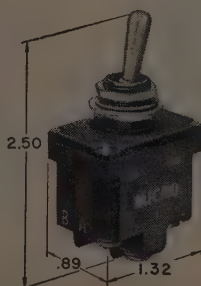


**4TP1-1**—Rocker-actuated key switch combines the advantages of both pushbutton and toggle manual control. Key is flat, like a pushbutton and can be engraved, but has toggle feature of visible position. Also enhances panel design and provides edge-light indication. Construction of case is rugged and sealed, with integral, stepped terminal design. 4-pole DT circuitry (others available). 28vdc rating: res. 20a., lamp 7a., ind. 15a. Data sheet 141.

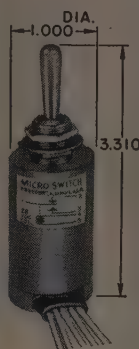
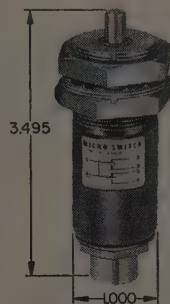


**2TL1-1**—Integral, stepped terminal design. High impact strength, arc resistant case. Silicone seal on bushing and self-sealing sealant between cover and case. 2-pole DT circuitry. Rating at 28 vdc: res. 20a., lamp 7a., ind. 15a. Available in variety of toggle positions. Data sheet 139.

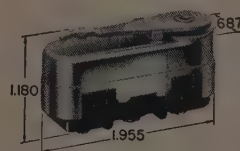
**4TL1-1A**—Same features as 2TL1-1 except toggle lever has safety feature which requires pull to unlock and move the lever. (Available in a variety of locking arrangements.) Knob facilitates operation with gloves. 4-pole DT circuitry. Rating same as 2TL1-1. Data sheet 142.



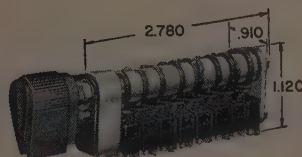
**1EN75-R**—High-impact shock switch for use on launching platforms, near jet after-burners, etc. Heavy duty push plunger with ice-mud scraper. Operating force 6-12 lbs., release force 4 lbs. Environment and immersion proof (MIL-S-901B, Navy and MIL-E-5272A, Proc. 1). Contains two SPDT switches. Available with straight (shown) or angle connector plug. Data sheet 152.



**5ET1-6**—Compact, magnetically-held toggle switch has a built-in 28vdc solenoid. Works as a momentary action toggle switch, but is converted to a maintained contact switch when solenoid is energized. Permits remote electrical release of the lever, thus eliminating auxiliary relays, etc. Toggle lever can be manually over-ridden. Environment and immersion-proof enclosure (MIL-E-5272A Proc.1). SPDT basic switch. 28vdc. rating: inrush 24a., resistive 4a., inductive 3a., motor 4a. Data sheet 121.



**1HS1 (MS-25011-1)**—Hermetic sealed construction (metal-to-metal or metal-to-glass seals). Contacts sealed in dry gas under pressure. SPDT. 28vdc rating: ind. 10a., res. 25a. Catalog 77.



**17AS8**—Compact rotary selector switch handles eight different circuits, requires only 1 1/4 inch diameter panel area. Switching sequence is infinitely variable. Data sheet 86.

## PRODUCT REVIEW

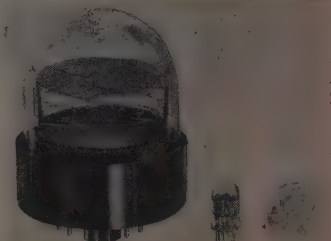
### VIDEO TERMINATION for 75-ohm coax lines

A new Video Termination, Type RF-300, for 75 ohm coaxial transmission lines is announced by Daven Co., Dept. S/A, Livingston, N. J.

Some of the unit's characteristics are: a turret type lug at the rear of the termination provides a connection point for an oscilloscope; negligible reactance (less than two deg phase shift) up to 250 MC; deposited carbon resistor rated at 1/2 W. Accuracy one per cent. RF resistance at 100 MC is within -1 per cent of the dc value. Terminations are housed in standard UHF type connectors.

Circle No. 133 on Reader-Service Card

### INDICATOR TUBE in large size



The Jumbo Nixie, Type BD-307, is a three-in-dia indicator tube with a numerical display that can be seen at distance of over 150 ft, says Electronic Tube Div., Burroughs Corp., Dept. S/A, Plainfield, N. J. It is designed for low power and ruggedness.

The all-electronic inline indicator contains the numerals zero through nine and utilizes a common anode for circuit simplicity. The desired numeral lights when a voltage is applied between it and the anode.

Circle No. 134 on Reader-Service Card

### WAVEGUIDE FILTERS have sharp cutoffs

This new line of r-f waveguide filters features very sharp cutoffs and low insertion loss in the passbands, says Microphase Corp., Dept. S/A, Box 1166, Greenwich, Conn. One unit in the line, a low-pass type, cuts off at five kmc/s, has a maximum loss of 0.75 db, and a minimum attenuation of 60 db from 1.08f. out to 12 kmc/s.

The unit, which handles up to 100 W of power, has a UG-149A/U flange at one end and a UG-148B/U at the other. Units in the S through X bands can perform similarly.

Circle No. 135 on Reader-Service Card  
more on next page

Circle No. 105 on Reader Service Card in Product Review Section



Precision Components . . . another Kearfott capability.

## high-temperature components

Kearfott components for missile and aircraft systems can provide optimum performance at temperatures as high as 200°C. Moreover, this peak performance is unaffected by 2000-cps vibration and 50-G shock. Kearfott's compact, light-weight and corrosion-resistant components provide this consistent record of accuracy:



**Synchros:** Sizes 8 through 25. Errors as low as 20 seconds from E. Z.

**Motor-generators:** Sizes 8 through 18. Linearity of 0.01%.

**Servomotors:** Sizes 8 through 25. Wound for transistorized amplifiers.

Kearfott research is continually developing even more accurate and more durable components . . . preparing for the needs of tomorrow. For details, write today or contact your nearest Kearfott sales office.

**Engineers:** Kearfott offers challenging opportunities in advanced component and system development.

# Kearfott



**KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.**

A Subsidiary of General Precision Equipment Corporation

Sales and Engineering Offices: 1378 Main Ave., Clifton, N. J.

Midwest Office: 23 W. Calender Ave., La Grange, Ill. South Central Office: 6211 Denton Drive, Dallas, Texas

West Coast Office: 253 N. Vinado Avenue, Pasadena, Calif.

Circle No. 94 on Reader Service Card in Product Review Section

## PRODUCT REVIEW

### RESISTORS are micro-miniature

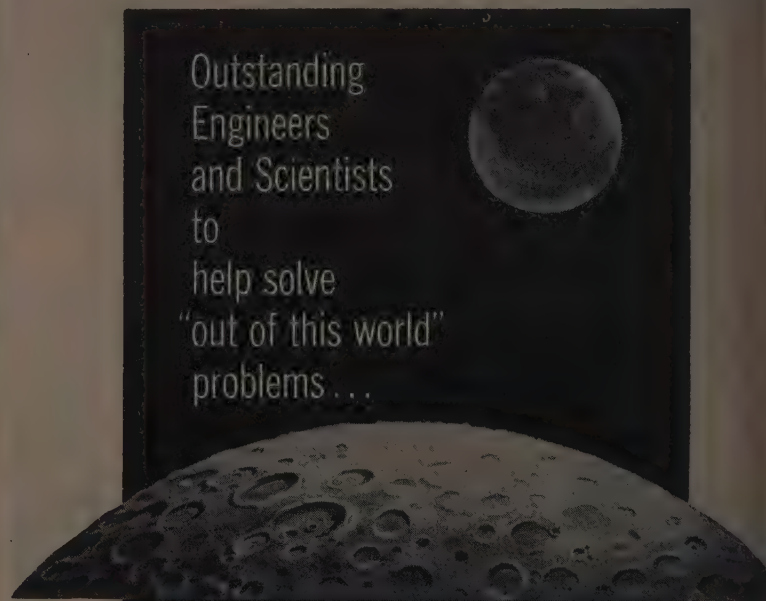
High resistance, very small size, and precision tolerances are featured in two micro-miniature, wirewound resistors made by Dale Products, Inc., Dept. S/A, Columbus, Neb. The smaller resistor, the RS-1A, is  $1\frac{1}{32} \times \frac{3}{32}$  in., and the other, the RS-1B,  $1\frac{1}{32} \times \frac{3}{32}$  in.

Both resistors are coated with a silicone covering for protection from thermal shock, humidity, salt

air, and similar environmental conditions. The devices are available in tolerances of 0.05, 0.1, 0.25, 0.5, 1, and 3 per cent. The RS-1A has a resistance range of 1-7500 ohms, and the RS-1B, a range 1-10,000 ohms, depending on tolerances. The smaller unit is rated at one W at 25 deg C and the larger at one W at 50 deg C.

Circle No. 136 on Reader-Service Card

Outstanding  
Engineers  
and Scientists  
to  
help solve  
"out of this world"  
problems . . .



Today artificial satellites orbit in space. Missiles can span continents. Conservative scientists calmly talk of landing on the moon.

Just as they have contributed to other aeronautical sciences, the various divisions of United Aircraft Corporation have made significant contributions to these new fields of missiles and space technology.

Recently the outstanding scientists and engineers who had specialized in missiles, missile guidance and space penetration problems in each division were brought together to focus their combined skills on advanced concepts and systems. A new Division was created . . . the Missiles & Space Systems Division.

This division is only weeks old. It is in an explosive growth period. Yet it has a built-in stability factor . . . the advantages of the brainpower, the "know-how", the financial resources and the unique facilities of a billion-dollar corporation that is already pre-eminent in aeronautics.

This combination of newness and stability should be significant to every alert engineer or scientist. It should suggest a unique opportunity to demonstrate ability and win the advancement and other rewards that ability deserves.

If you are looking for opportunity, we suggest that you contact us immediately.

Positions are available at all levels in . . .

**ELECTRONICS:** Guidance, Radar, Countermeasures, Computers, Telemetry • **SYSTEMS ANALYSIS** • **SYSTEMS INTEGRATION** • **MILITARY REQUIREMENTS** • **RELIABILITY** • **GROUND SUPPORT** • **SPACE TECHNOLOGY:** Astrophysics, Astronautics • **AERONAUTICS:** Preliminary Design, Performance, Aerodynamics, Structures, Propulsion.

Please send your complete resume, including salary requirements, to Mr. John C. North.

## MISSILES & SPACE SYSTEMS

DIVISION OF UNITED AIRCRAFT CORPORATION • EAST HARTFORD 8, CONN.



When your project calls for

**SMALLEST PACKAGING**

**LIGHTEST WEIGHT**

**TIGHTEST COUPLING**

**LOWEST PHASE SHIFT**

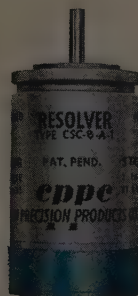
**LOWEST NULLS**

**HIGHEST ACCURACY**

IN

**SYNCHROS**

Look to CPPC Size 8's



ACTUAL SIZE

SYNCHRO FUNCTION	CPPC TYPE	PRIMARY					D. C. RESISTANCE			IMPEDENCE			Max. Voltage Voltage (MV)	ACCURACY Max. Error (Min.)
		Input Voltage (400~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	Rotor (Ohms)	Stator (Ohms)	Z <sub>ro</sub> (Ohms)	Z <sub>2n</sub> (Ohms)	Z <sub>rsn</sub> (Ohms)		
Torque Transmitter	CGC-8-A-7	26	.100	.54	11.8	206	8.5	37	12	54 + j260	12 + j45	80 + j20	30	7
Control Transformer	CTC-8-A-1	11.8	.087	.21	23.5	411	9	143	24	210 + j690	28 + j114	250 + j73	30	7
Control Transformer	CTC-8-A-4	11.8	.030	.073	22.5	393	8.5	365	64	470 + j1770	81 + j330	590 + j190	30	7
Torque Receiver	CRC-8-A-1	26	.100	.54	11.8	206	8.5	37	12	54 + j260	12 + j45	80 + j20	30	30 sp.
Electrical Resolver	CSC-8-A-1	26	.038	.39	10.8	189	20	230	27	270 + j630	39 + j142	340 + j67	30	7
Electrical Resolver	CSC-8-A-4	26	.038	.39	26	454	20	230	170	270 + j630	250 + j830	340 + j67	30	7
Control Differential	CDC-8-A-1	11.8	.087	.21	11.5	204	11	36	24	38 + j122	28 + j114	47 + j13	30	7
Vector Resolver	CVC-8-A-1	26	.100	.54	11.8	206	11	37	16.5	54 + j260	19 + j60	80 + j20	30	7

Circle No. 90 on  
Reader Service Card  
in Product Review  
Section

CLIFTON PRECISION PRODUCTS CO., INC.

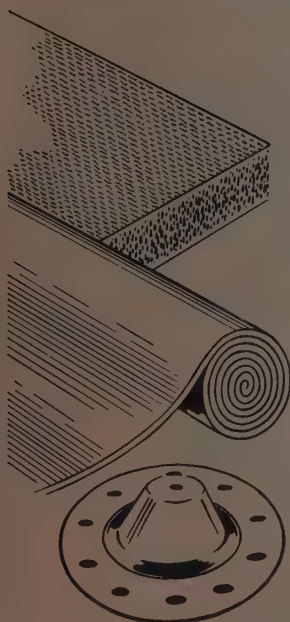
**cppe**

Clifton Heights, Pa.



# IN SILICONES OR RUBBER

## WHAT'LL YOU HAVE?



**SPONGE?** Chemically blown, closed-cell silicone sponge is available in fine, medium, and firm density; skin thickness can be varied to suit. Excellent for gaskets, seals, shock mounts, light duty press pads, die cut parts.

**SHEET?** Solid sheet is produced from 1/32 to 1 in. thick, 20 to 80 durometer, in compounds to meet all AMS, ASTM, and military specifications. For gaskets, seals, bushings, die cut parts, diaphragms, heavy duty press pads. Laminated press pads and throw sheets are also available.

**MOLDED PARTS?** Diaphragms, pipe coupling gaskets, regulator parts, medical kit liners, bumpers, flexible coupling discs, spring inserts, aircraft test sleeves, and many other components are produced to rigid specifications.

Hewitt-Robins, prominent in development of aircraft refueling hose, makes many silicone and rubber products for the aircraft and missile industries. These components are fabricated using all elastomers, including silicones by themselves or with various fabric or metal reinforcements.

Specialists in our Aircraft Products Department can help you put today's new compounds to best use in aircraft, missiles, and rockets. For information, service, or your copy of comprehensive Product Bulletins, contact your local H-R representative, or Hewitt-Robins, Stamford, Connecticut.



## HEWITT-ROBINS

CONVEYOR BELTING AND IDLERS... POWER TRANSMISSION DRIVES  
INDUSTRIAL HOSE... VIBRATING CONVEYORS, SCREENS & SHAKEOUTS

H-R Product Manufacturing Plants in Buffalo, N.Y. • Chicago, Ill. • King of Prussia, Pa. • Passaic, N.J.  
Amsterdam, Holland • Johannesburg, South Africa • London, England • Montreal, Canada • Paris, France

Circle No. 99 on Reader Service Card in Product Review Section



**ANALOG-DIGITAL CONVERTER**—Its new shaft analog-to-digital converter is described in Brochure D1.03 by Data Instruments Div., Dept. S/A, Telecomputing Corp., 12833 Saticoy St., North Hollywood, Calif. Typical pulse output waveforms are shown.

Circle No. 137 on Reader-Service Card

**TAPE PROCESSING**—Special tape processing equipment is described in a six-page brochure by Digitronics Corp., Dept. S/A, Albertson, N.Y. Units are available singly or in combinations.

Circle No. 138 on Reader-Service Card

**CAPACITOR**—Its high-Q voltage-variable Semicap capacitor is described in Bulletin SR-205 by International Rectifier Corp., Dept. S/A, El Segundo, Calif. Design and performance specs are given.

Circle No. 139 on Reader-Service Card

**MAGNETIC SHIELDING**—Manual 101-122 summarizes design and fabrication techniques for Netic and Co-Netic magnetic shielding, made by Magnetic Shield Div., Perfection Mica Co., Dept. S/A, 1322 N. Elston Ave., Chicago 22, Ill. Test techniques for shielding evaluation are also covered.

Circle No. 140 on Reader-Service Card

**PULSE TRANSFORMERS**—A series of encapsulated miniature pulse transformers is described in a technical bulletin by Technitrol Engrg. Co., Dept. S/A, E. Allegheny Ave., Philadelphia 24, Pa. The units are wound on high-permeability ferro-magnetic cores.

Circle No. 141 on Reader-Service Card

**VOLTAGE REFERENCE SOURCES**—One binary and two decade models of its voltage reference sources are described by Epsco, Inc., Dept. S/A, 588 Commonwealth Ave., Boston, Mass., in four-page Bulletin 95806.

Circle No. 142 on Reader-Service Card

**RESISTORS**—Catalog Gr-20 tells of bobbinless precision wire-wound resistors and is available from General Transistor Corp., Dept. S/A, 91-27 138th Place, Jamaica 35, N.Y.

Circle No. 143 on Reader-Service Card

## data review . .

**SEMICONDUCTORS**—Importance of impurities in semiconductor alloys is one of the things illustrated in the technical bulletin offered by Accurate Specialties Co., Dept. S/A, 37-11 57th St., Woodside 77, N.Y.

Circle No. 144 on Reader-Service Card

**POTENTIOMETERS**—Data Sheet 1362 tells about the Helipot Series 5200 all metal, 1 1/16-in.-dia servo-mounting precision potentiometers. It is available from Helipot Div., Beckman Instruments Inc., Dept. S/A, Fullerton, Calif.

Circle No. 145 on Reader-Service Card

**RADAR SYSTEMS**—The radar antenna system designed for ultra-precision tracking of the Talos missile is described in a bulletin published by Special Product Div., I-T-E Circuit Breaker Co., Dept. S/A, 601 E. Erie Ave., Philadelphia 34, Pa. This 4-page bulletin describes the designing, fabrication and testing of a prototype antenna system to specs within 13 months.

Circle No. 146 on Reader-Service Card

**TRANSISTOR DIGITAL CIRCUIT**—An 8-page booklet is being offered by Epsco Inc., Dept. S/A, 558 Commonwealth Ave., Boston 15, Mass. It concerns the transistor digital circuits series 100.

Circle No. 147 on Reader-Service Card

**WAVE TUBES**—A bulletin concerning backward and forward wave amplifiers and backward wave oscillators has been published by Huggins Laboratories Inc., Dept. S/A, 711 Hamilton Ave., Menlo Park, Calif.

Circle No. 148 on Reader-Service Card

**TEST EQUIPMENT**—An 84-page catalog describing its expanded line of microwave and UHF test equipment and components is being published by The Narda Microwave Corp., Dept. S/A, 118-16 Herricks Road, Mineola, N.Y.

Circle No. 149 on Reader-Service Card

**FILTERS**—Burnell & Co., Dept. S/A, 10 Pelham Parkway, Pelham N.Y., is publishing Catalog 10 which stresses the importance of toroids, filters and related networks in military and industrial communications.

Circle No. 150 on Reader-Service Card



**MECHANICAL STOPS**—Data sheet 80-10 gives details on the mechanical devices made by Keafott Inc., Dept. S/A, 1378 Main St., Clifton, N. J., for stopping motion at predetermined intervals.  
Circle No. 151 on Reader-Service Card

**FAILURE PREDICTION** — Bulletin 11 describes a test procedure for lab, production, and field maintenance developed by Associated Research, Inc., Dept. S/A, 3777 Belmont Ave., Chicago 18, Ill., for a wide variety of electronic and electric equipment to forecast failure.  
Circle No. 152 on Reader-Service Card

**CIRCUIT POLARIZATION** — Report 3 describes the circular polarization feed designed by I-T-E Circuit Breaker Co., Dept. S/A, 601 Erie Ave., Philadelphia 34, Pa., for airport radars.  
Circle No. 153 on Reader-Service Card

**INTERFERENCE METERS** — Five meters—NM-10A, -20B, -30A, -40A, and -50A—from Stoddard Aircraft Radio Co., Inc., Dept. S/A, 4 Santa Monica Blvd., Hollywood 38, Calif., gives specs and calibration data on radio interference and field intensity measuring instruments for 30 cps to 1000 mc.  
Circle No. 154 on Reader-Service Card

**INSULATED WIRE**—A technical bulletin is available from Hitemp Wire, Inc., Dept. S/A, 1200 Ames Dr., Westbury, N. Y., on the company's Ceramtemp insulated wire for continuous operation at 1000 deg. F.  
Circle No. 155 on Reader-Service Card

**ATTITUDE REFERENCE**—Its two-part, all-attitude master reference, designed for several recent fighters, described by Lear, Grand Rapids, Dept. S/A, 110 Ionia Ave., Grand Rapids 2, Mich., in a catalog sheet.  
Circle No. 156 on Reader-Service Card

**CROWAVE PARTS** — Catalog T3 has been issued by T.E.M., Dept. S/A, 71 Okner Pkwy., Kingston, N. J., describing signal amplifiers, monitor tees, and decouplers and blocks for the microwave region.  
Circle No. 157 on Reader-Service Card



**Something to see...**

**for the pilot who's flying blind**

Autonetics' new Pilot Display Projector is another milestone in the elimination of blind-flying problems. It projects onto a special transparent screen, in the pilot's normal forward view, a bright replica of any instrument display, or combination of displays, that can be put on a cathode ray tube. The pilot is not distracted, as with other systems, by having to look down repeatedly at an indicator. And—since the display is transparent—his normal view through the windshield is unobstructed. Autonetics' Pilot Display Projector was originally developed for the Army-Navy Helicopter Instrumentation Program, but is adaptable to fixed-wing aircraft.

A DIVISION OF NORTH AMERICAN AVIATION, INC. - Downey, California **Autonetics** 



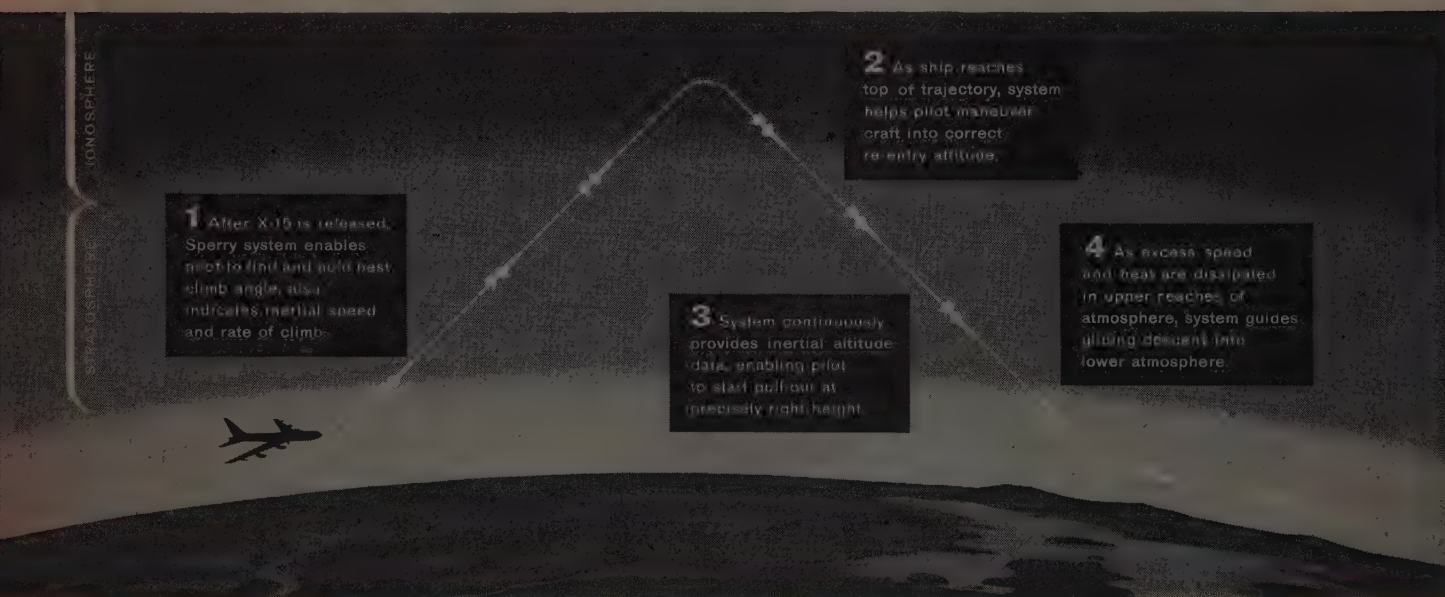
## THE STORY BEHIND THE STORY



**HYPERSONIC X-15**, powered by a mighty rocket engine, will follow bullet-like trajectory during flight, similar to path of ballistic missile.



**WEARING SPECIALLY-DESIGNED SPACE SUIT**, X-15 pilot is protected against environmental extremes as he maneuvers the rocket to the edge of space.



# X-15 WILL THRUST 100 MILES INTO SPACE UNDER CONTROL OF NEW INERTIAL SYSTEM

Strapped firmly into his cockpit, an Air Force pilot soon will ride the North American X-15 rocket research ship 100 miles and more into the sky at speeds above 3600 mph—over a mile a second.

A highly advanced Sperry inertial system, developed in conjunction with the Flight Control Laboratory of Wright Air Development Center, will supply control data for this historic venture. When the pilot and his revolutionary craft drop from a B-52 jet bomber, the inertial system will give him data for maneuvering and navigating the X-15 with extreme accuracy. As the stainless steel research

plane flashes outward through the thinning atmosphere, the Sperry system will "show" the pilot how to correct for even the smallest deviation from flight path. It will display flight information on specially developed instruments; at the same time feeding the data to ground and airborne recorders for a permanent record of the flight.

An important additional contribution of the Sperry system will be to guide the pilot in bringing the X-15 safely back into the earth's atmosphere. During this critical phase of the flight, attitude of the X-15 on re-entry must be precisely con-

trolled to avoid exceeding its structural limitations.

On this daring journey into space, the super-sensitive Sperry system will have to function perfectly under conditions ranging from extreme acceleration to complete weightlessness, through temperature swings that may heat the X-15's exterior to 1,000 degrees in a few seconds.

**SPERRY** *GYROSCOPE COMPANY*  
Great Neck, New York

DIVISION OF SPERRY RAND CORPORATION

Circle No. 104  
Reader Service  
in Product Review  
Section



# aircraft • missile engineering intelligence

## **Atlas tests to be speeded up after successful full range flight**

FIRST FULL RANGE (6300-mile) firing of Convair Atlas ICBM from Cape Canaveral will result in a speed-up in Atlas tests. Present plans call for the firing of one Atlas a month.

AF's jubilation over the full ICBM flight will not result in any downgrading of the Martin Titan ICBM, however. USAF still considers the Titan (about one year behind the Atlas program) a more sophisticated weapon system.

## **IRBM orders may be smaller than expected**

THE ATLAS FLIGHT may influence the IRBM program. Defense Department, under orders to choose either Douglas's Thor or ABMA-Chrysler's Jupiter for large scale production, will do just that. But orders for the IRBM that is selected may be smaller than expected. USAF will be less dependent on foreign IRBM launching bases now that Atlas has proved completely successful.

## **Valkyrie may carry IRBM armament, says USAF**

NAA B-70 "CHEMICAL" BOMBER, now under development, will probably fire an air-launched IRBM, according to Lt. Gen. Roscoe C. Wilson, USAF's Deputy Chief of Staff for Development.

Components of this solid propellant WS-199B IRBM are already being tested by Lockheed and Martin. One version of it is identified as Bold Orion.

## **Two-stage IRBM will be larger than Bullpup, may also be carried by B-47 and B-52**

IF IT CAN BE READY before the B-70 Valkyrie bomber is delivered, WS-199B may also be used on B-47s and B-52s. The two-stage missile is similar to, but larger than, the Bullpup and White Lance air-to-surface missiles Martin is building for Navy and USAF.

Until the WS-199B is available, USAF will continue to hedge its bet with the NAA Hound Dog. First production contract for the GAM-77 (worth \$19 million) was placed by Air Materiel Command last month. Powerplant is the 7500-lb thrust P&WA J52. The bird will use an Autonetics self-contained inertial guidance system. Warhead is nuclear.

NAVY gave Martin-Orlando a \$20.4 million order for the short range Bullpup ASM. The Bullpup, which is just entering fleet service, is guided by the pilot by radio. An Aerojet-General rocket engine provides Mach 2 speeds. Range is 15,000 ft.

## **Latest A4D version can fly non-stop from coast to coast without refueling**

THIRD VERSION of the Douglas lightweight Skyhawk attack plane has been ordered by the Navy. A4D-2N will be produced at El Segundo under a contract totaling more than \$79 million.

Newest Skyhawk again uses C-W J65. It can reach top speeds of 700 mph and fly non-stop coast-to-coast without refueling. A night attack plane, it has basically the same airframe as earlier Skyhawk but is almost a foot longer. It can carry machine guns, missiles, rockets, and atomic weapons.

## **DC-8 jetliner test flights are in full swing at Douglas**

WITH ITS LAST DC-7C delivered, Douglas is concentrating on speeding up testing and deliveries of the DC-8 jet transport.

First DC-8 powered by P&WA J75s has been flight-tested. Douglas now has four DC-8s flying, including three domestic versions fitted with J57s. It expects to use nine planes (including some powered by Rolls-Royce Conways) in its CAA test program.

Airline service with the DC-8 begins next fall.

## **GE comes up with closed-center hot gas servo in record time**

CLOSED-CENTER HOT GAS SERVO was developed by GE's Aircraft Accessory Turbine Dept., Lynn, Mass. Up to now, many application engineers felt a practical closed center system—if possible at all—was still a few years off (see S/A, "What's the Outlook for Hot Gas Servos?", Nov. '58, p. 20).

FEATURES OF GE'S servo design include: high frequency response through pressure-type control, electrically controlled damping, adjustable stiffness and

more on next page



accuracy characteristics independent of hardware changes, poppet valves to reduce leakage and sensitivity to gas flow contaminants, and symmetrical construction to reduce thermal shock problems.

**SIMPLE** method for re-entry studies has been worked out at Temple University's Research Institute, Elverson, Pa. Nose cone scale models made of refractory materials are inserted into extremely hot rocket exhaust flames, and the rate of ablation or sublimation is measured photographically.

Some correlation work is needed to draw conclusions about aerodynamic heating from these tests. Still the high heat flux of the rocket exhaust is sufficiently similar to that of re-entry to make the Temple researchers' relatively cheap setup—built around a rocket with a two-inch diameter exhaust nozzle—worth while.

## **\$29.3 million contracted for Titan underground launch**

**UNDERGROUND** launching system for Titan ICBM will be developed by American Machine & Foundry. Design and development contract for \$29,300,000 includes launcher system and related handling equipment.

**PROPELLANT** ignition problems on top of combustion instability are hampering development of large solid boosters in the 80,000 lb-and-over class for Polaris, Pershing, and Minuteman. Specs call for ignition reliability at temperatures below 10 deg F. The huge solid

grains can be ignited at these temperatures, but they resist uniform ignition. Once they do ignite, they start violently and in many instances quench the initial combustion process.

U. S. **NUCLEAR** turbojet engine is expected to be flying by '61. Reports of thrust rating vary from a low of 70,000 lb to high of over 80,000 lb.

## **Dual bypass planned for U. S. airborne reactor?**

**NUCLEAR** engine design is said to have a dual bypass feature. (Russians pooh-pooh practicability of such an engine.) Idea is for turbojet to operate on chemical combustion heat during takeoff, on nuclear reactor heat during cruise.

**INTAKE** diameter reportedly is more than eight feet. During takeoff, air bypasses the reactor to enter annular conventional combustion chambers clustered around the reactor. Products of combustion are then re-routed to follow normal exit.

During cruise, air is directed through the reactor core, passes through the turbine wheel, and is ejected at subsonic speeds at around 1400 deg F.

**LOBBER** cargo ballistic missile developed for the Army by Convair was originally designed to deliver supplies (ammunition, rations, medicines, etc.) to advance troops isolated by enemy action or terrain. But Army feels Lobber may have other uses, too—among them laying down radio

transmitters as radio bench marks for rapid forward area surveys, sending cables across impassable waters for pontoon bridge construction, and stringing steel communications wire to forward observers.

**W2F-1 EARLY-WARNING** turboprop being developed by Grumman has been called "highly advanced and more heavily instrumented" replacement for the Navy's interim WF-2 Tracer. Power for the new plane will be supplied by two Allison engines.

**ORENDA IROQUOIS** turbojet scheduled to power the on-again, off-again CF-105 Avro Arrow has successfully logged over 100 hours in Lewis wind tunnel. Orenda-patented system for normal relights at critical Mach numbers following flameout worked well up to simulated altitudes of 60,000 ft (the maximum altitude capability of the tunnel).

**WITH THE PROTOTYPE** of the T-38 jet trainer due to make its first flight this month, AF gave Northrop \$17 million order to produce the supersonic T-38A as a production item.

The order is the first of a series of USAF contracts for the trainer, which will be used to transition pilots from the subsonic T-37 jet to century series fighters.

**ARDC** tentatively agreed to a Lockheed Aircraft proposal to retrofit the F-104 with upward ejection seats. Lockheed's experience shows most F-104 problems unexpectedly have been at low altitudes (with power settings critical).

The F-104 was one of the first production aircraft to be

equipped with downward ejection seats.

**LOCKHEED'S XQ-5** supersonic ramjet target drone was successfully intercepted by the Army's Hawk and Nike-Hercules. It was shot down by Hercules at altitudes over 60,000 ft while traveling at 1500 mph. Hercules has also proved effective against the Pogo-Hi target at altitudes over 100,000 ft.

## **Valves most critical in missile servo hydraulics**

**SERVO** valves are most critical components of hydraulic servo systems for missiles, J. W. Kastle, Jr., of Raytheon Missile Systems, told recent Vickers Hydraulic Conference in Detroit, Mich. Major effort is needed, he said, to perfect servo valve-actuator combination for pressures of 4000-5000 psi with much lower null leakage.

Null leakage, Kastle noted, will be increasingly important in large missiles of future—pumps will be held to 90 per cent minimum efficiency with only servo valves with flat P/Q curves specified. One point of improvement in these units is electric solenoids, many of which in today's systems are marginal at best, Kastle said.

**CURRENT** testing of hydraulic servo systems, Kastle said, indicated vibration is most likely to induce component failure and acceleration least likely.

**HOT GAS** servo work at Vickers looks promising, F. Klemach told the Confer-



# How **ESNA** solves 7 typical aircraft fastening problems



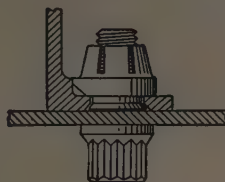
## Speedier installation of access panels

ESNA gang channel nut strips eliminate the costly, time consuming installation job of riveting individual nuts. Available in straight or curved sections and even complete rings, custom designed for applications such as access doors or inspection covers.



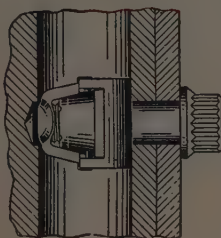
## Bolting non-parallel surfaces

No more costly spot facing, step milling or hand selecting tapered shims! ESNA's counterbored, self-aligning types include one lug, two lug, gang channel, standard hex and high tensile types. Ball-and-socket relationship of nut and special base allow an 8° tilt in any direction from centerline to compensate for draft angle or tapered sections.



## Fastening stressed joints subject to temperatures up to 1300°F.

For really "hot" applications such as jet engine flange assemblies or fire wall sections, where fastener dependability is critical, ESNA offers the "long-beam" locking device. The full cantilever of these sections assures protection against failures related to relaxation, creep and similar problems caused by the effects of extremely high temperatures upon metals. (Ask for ESNA Bulletin No. 5715 Design Manual for High Temperature Self-Locking Nuts.)



## Simplifying major substructure joining

An ESNA barrel nut doesn't have to be held for wrenching... doesn't need precisely mated bolt holes. The barrel-shaped fastener is simply fingerpressed into a drilled or reamed hole until the special clip snaps into position at the bolt hole location. The .030" float of the nut section of this fitting avoids misalignment problems and the bathtub recess for wrenching area is eliminated. New NAS 577 barrel nut (180,000 psi) now available. Also 160,000 and new 220,000 psi series.



## Applications requiring guaranteed high reusability through more than 50 on-off cycles.

Where repeated tear-down and re-assembly or frequent readjustment is required, the exceptional elastic "memory" and non-galling characteristics of ESNA's standard nylon locking insert guarantees long lasting locking torque and fastening dependability. Available in all sizes and configurations of standard aircraft type nuts. Parts can also be designed to order and in any standard configuration, with guaranteed re-use factors as high as 300 on-off cycles.



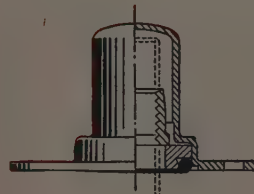
## Attaching components in areas with limited wrench clearance.

Miniaturized insert-type hex nuts with across-the-flats dimensions as small as .109 in the 0-80 size... or all metal (550°F.) nuts to AN365 or NAS 679 performance specifications with internal wrenching hexagon faces (which permit use of smaller wrench sizes) are available for use at locations where space and weight limitations are paramount. Complete lines of NAS miniature anchor nuts in carbon steel and A286 stainless steel are also in production. Ask for your copy of the NAS/ESNA Conversion Book.



## Sealing against fuel tank leakage

No danger of highly volatile fluids leaking past bolt threads with ESNA's self-sealing, floating anchor cap nut! The one piece cap unit is provided with "O"-ring seal around its base which seals immediately the nut is riveted to the surface. The self-locking nut enclosed within the cap has .025" float to compensate for misalignment. Also available in gang channel nut strips.



## --- WHAT ARE YOUR FASTENING PROBLEMS? ---

Dept. N49-150, Elastic Stop Nut Corporation of America  
2330 Vauxhall Road, Union, N. J.

Please send me details on the following:

- |  |   |
|--|---|
| <input type="checkbox"/> Installing access panels      | <input type="checkbox"/> Simplifying substructure joining                 |
| <input type="checkbox"/> Sealing against leakage       | <input type="checkbox"/> Assuring high re-usability                       |
| <input type="checkbox"/> Fitting in limited space      | <input type="checkbox"/> NAS/ESNA Conversion Book                         |
| <input type="checkbox"/> Bolting non-parallel surfaces | <input type="checkbox"/> Bulletin No. 5715 High Temperature Design Manual |

Name \_\_\_\_\_ Title \_\_\_\_\_

Firm \_\_\_\_\_

Street \_\_\_\_\_

City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

**ELASTIC STOP NUT CORPORATION  
OF AMERICA**



ce. Present setup has hot generator feeding integral, positive-displacement hot gas motor-hydraulic pump combination. Positive-displacement machine was chosen because rotational speed closely matches that of either electric generators or hydraulic pumps. This eliminates the gear box normally needed with small, high speed turbine drives.

ROPELLANTS are available, Klemach said, that give combustion chamber pressures of 500-3000 psi, temperatures of 1500-2500 deg F. Most tickers work thus far has been about 1000 psi and 2000 deg F, but program is being expanded.

Solid propellants look best for operating times of several minutes or less, said Klemach. For longer times, liquid propellants offer low sfc, which usually means lower installed weight and smaller space envelope.

RIES of tests was run using combustion of hydrogen and oxygen. One such run resulted in flame temperatures of 5000-2000 deg. F. After 30 sec under these conditions, Klemach said, motor was found in excellent shape on disassembly.

FLUIDS to meet all needs for 000-450-deg F hydraulic system operation will probably be available in next few years, R. D. Montgomery, Vickers engineering section chief told the Conference. For temperatures over 400 deg F, he stated, metal or non-elastomeric seals will probably be needed.

Vickers is now studying ways of heating hydraulic fluids from -65 to between -20 and zero deg F. Such heating would make it possible to

more on next page



## Raytheon Missile Projects



**SPARROW III**—the Navy's tenacious, lightning-fast, air-to-air missile—is intended for extensive use by Navy fighter aircraft in fleet air defense. Sparrow III is a Raytheon prime contract.



**HAWK**—the Army's defense against low-altitude attackers—carries out its destruction in the blind zone of conventional radars. Hawk development and production is under Raytheon prime contract.



**TARTAR**—A substantial contract for vital electronic controls for this Navy destroyer-launched missile is held by Raytheon. This equipment—a tracking radar and associated units—enables it to "lock on", cling to target's path, despite evasive tactics.



**ADVANCED PROJECTS** in aeronautical structures as well as missile guidance and control are now underway in Raytheon laboratories. New facilities are continually being added for this work.



**PRELIMINARY NEW DESIGNS** of tomorrow's missiles will result from the advanced work being done by today's missile engineers. Raytheon plays an important role in this area.

Raytheon diversification offers

# JOB STABILITY FOR CREATIVE MISSILEMEN

Here is an opportunity to free yourself of worry about a job that's here today, gone tomorrow.

**Diversified assignments**—only possible in a company with Raytheon's wide range of missile activities—means security not found in one- or two-project companies. You apply your creative energies to the many projects you work on, and they in turn are your "insurance" against falling into a rut.

**Individual recognition** comes quickly from Raytheon's young, engineer-management—men who are keenly aware of the engineer's needs and contributions to missile progress.

**Dynamic Raytheon growth**—the fruit of this management's progressive policies—is best illustrated by the fact that Raytheon is already the only electronics company with two prime missile contracts—Navy Sparrow III and Army Hawk.

**The next step is up to you.** Why not get frank answers and helpful information on the type of job suited to your background and talents, its location, salary and other important details. Write, wire or telephone collect: The number is CRestview 4-7100 in Bedford, Massachusetts. Please ask for J. Clive Enos.

## RAYTHEON OPPORTUNITIES NOW OPEN IN:

**WEAPONS SYSTEM ANALYSIS • CONTROL SYSTEMS • PACKAGING • MICROWAVE • RADAR • SPECIFICATIONS • MISSILE AERODYNAMICS • WIND TUNNEL TESTING • AERODYNAMIC HEATING • ROCKET ENGINEERING • VIBRATION MEASUREMENT and DATA REDUCTION**

**RAYTHEON MANUFACTURING COMPANY**  
Missile Systems Division, Bedford, Mass.



## ENGINEERING INTELLIGENCE

sible to use fluids with good high temperature properties whose pour points are too high for present specs.

**CONTAMINANT - TOLERANT** pumps are needed to meet increased reliability needs of future systems. Montgomery stated. Vickers pump of this type was subjected to contaminant three times higher than called out in military specs (filters were removed; contaminants included ferrous oxide, iron fillings, road dust) and survived 40-hr run. Leakage rate went up to 250 per cent, but volumetric efficiency only went down from 98 to 95 per cent. Standard lightweight units subjected to the same conditions, Montgomery noted, failed in less than one hour.

## Thorough analysis, better materials gave tolerance

**CONTAMINANT tolerance** was achieved, Montgomery said, by careful analysis of all surfaces and replacement of conventional materials in high-wear locations with more wear-resistant material. For instance, Vickers went to modular ductile iron-type cylinder block and ductile iron bore instead of bronze units.

**PROTOTYPE** Huckbolt fasteners with automatic hole sizing feature were demonstrated by Huck of Detroit, Mich., at Los Angeles fastening symposium. One type has integral extruding land, other type four-tooth progressive broach integral with pin. Latter produces interference fit between hole that is pin-shank-controlled within 0.001 in. during manufacture, Huck engineers state. This close control, it is claimed, eliminates all secondary broaching or reaming when leakproof design is called for.





**Whatever the shape  
of things  
to come . . .**

58-16

Fantastic shapes for the space vehicles of the future already are on the boards. Even more radical designs are taking form in the minds of engineers. And their parts and components will just as radically differ from those produced today. New standards of precision and new methods of working new materials will be required.

One thing at least is certain: the same design, development and manufacturing experience which made the transition from aircraft piston engines to jets will be needed to produce these shapes of the future. Since the early 1920's, Ex-Cell-O has been among the major suppliers of machines, parts and assemblies to the aircraft industry. In that time it has built a reputation for extending the frontiers of precision.

Today, Ex-Cell-O manufactures such components

as: rotors, blades, fuel nozzles, actuators, valves and fuel controls. Tomorrow? Well, perhaps you yourself have a problem which Ex-Cell-O's long experience in the production of precision controls and assemblies might help you solve. If so, why not contact Ex-Cell-O today?

EX-CELL-O FOR PRECISION



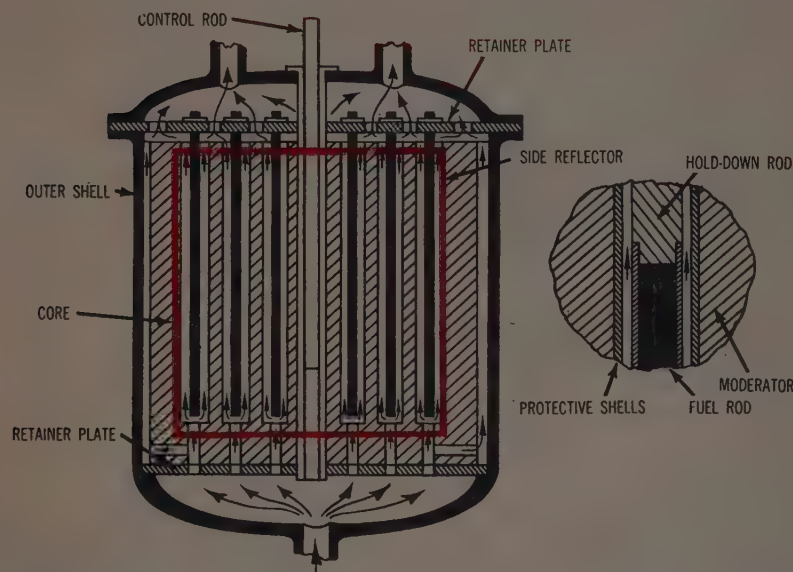
**EX-CELL-O**  
CORPORATION  
DETROIT 32, MICHIGAN

*Aircraft  
Division*

Circle No. 255 on  
Reader Service Card  
in Product Review  
Section

MAN AND MISSILES FLY HIGHER, FASTER AND SAFER WITH PARTS AND ASSEMBLIES BY EX-CELL-O.





POSSIBLE basic layout for a nuclear reactor. Section at right shows flow of liquid heat transfer agent for heat dissipation.

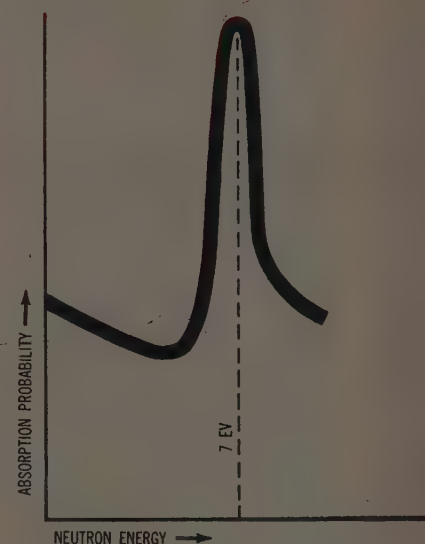


FIGURE 1: Neutron absorption probability for uranium 238 increases sharply when resonance absorption comes into play.

## Soviet development of nuclear aircraft engines

It's generally acknowledged by now that the Reds are hard at work on atomic aircraft—and probably ahead of the U.S. in this field. Clues to the approach taken by Russia's nuclear designers are given in a detailed, authoritative Soviet report published in three parts by SPACE/AERONAUTICS. This first article deals with general design features; next month's article will take up control problems.

by G. N. Nesterenko, A. I. Sobolev and  
Yu. N. Sushkov\*

LET us assume an atomic aircraft weighs 150 metric tons (165,375 tons), and has a very advanced aerodynamic form. To fly at Mach 1 at 11 km (36,091 ft), this aircraft must have a nuclear reactor putting out about 300,000 kw. (This is about twice the power of the reactor in the Soviet atomic ice-breaker.) For flight at Mach 1.5 at 11 km, the re-

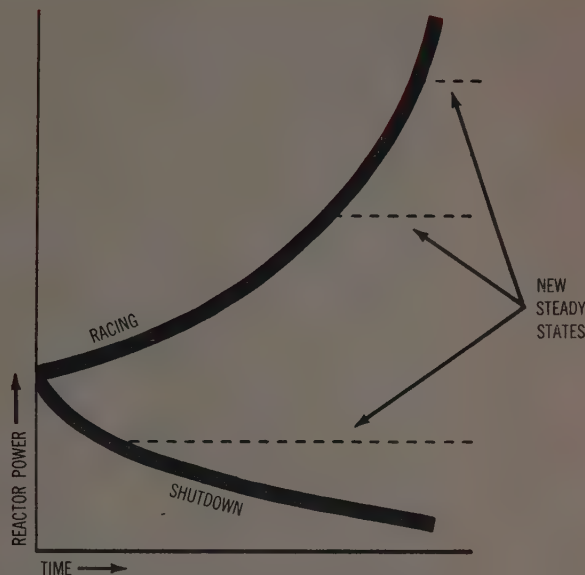
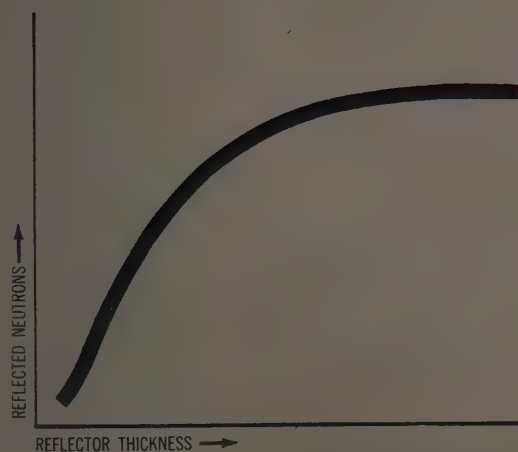
actor would have to put out about 900,000 kw.

These high powers must be obtained within the smallest possible dimensions. This will keep down the weight of casing and shielding. The great weight of the shielding is one of the major obstacles in designing atomic aircraft.

The aircraft reactor must be a high temperature type. The higher the temperature in the reactors, the smaller and lighter and the more efficient will be the reactor. Calculations show that, to get the flight

\*This is a condensation of "Primeneniye Atomnykh Dvigatelay v Aviatstii" (Application of Atomic Engines in Aviation), Military Press of USSR Defense Ministry, Moscow, '57. A partial translation is available as "PB 131908T" at \$3 from Dept. of Commerce, Office of Technical Services, Washington 25, D.C.





**FIGURE 2:** Effect of gradual increase in reflector thickness on number of reflected neutrons is sharpest at layers close to core.

**FIGURE 3:** Effect of "racing" and shutdown at 0.0025 excess reactivity and new steady states that can be attained.

characteristics for chemically fueled aircraft now in series production in a nuclear plane, the reactor surfaces must be heated to not less than 1000 deg C.

An aircraft reactor finally must be highly reliable in operation. Unlike stationary reactors, it must function normally no matter what its attitude in space. Also, it must not be affected by inertia loads caused by changes in speed or direction.

The major processes in an atomic reactor are the controlled fission chain reaction and the dissipation of the heat generated by this reaction. The fission reaction occurs in the reactor's active section, or core.

Nuclear fuel in the form of cylindrical rods protected by metal casings is placed in grooves in a solid moderator. The heat of the reaction is dissipated by a liquid heat transfer agent. A rod made of a good neutron absorber controls the reaction.

The collision of neutrons with atomic nuclei of various

materials, including nuclei of fuel, isn't always accompanied by neutron capture. Often the neutrons bounce off the nuclei, transferring to them a portion of their kinetic energy. As a result, they slow down. In addition, a change in the direction of their motion, or neutron scattering, takes place. This moderation process is artificially induced whenever a rapid reduction in neutron energy is needed.

#### Scattering may slow down neutrons

Secondary neutrons escaping on nuclear fission have a very high kinetic energy at "birth"—1-2 mev for "fast" neutrons, which include more than half of all secondary neutrons. In the scattering process, the kinetic energy of neutrons may decline to the energy level of the thermal motion of the particles in the surrounding medium. The energy of such "slow," or thermal, neutrons depends on the temperature of the surrounding medium—at 20 deg C, it is about 0.025

ev; at 700 deg C, it is about 0.085 ev. Neutrons whose kinetic energy falls between the "fast" and "slow" ranges are "intermediate" neutrons.

Neutrons loss is caused by the capture of neutrons (1) by fuel nuclei without subsequent fission (2) by nuclei of other materials used in the reactor; (3) by nuclei of fission products. Like scattering, such neutron absorption is inevitable, since all known materials absorb neutrons to some degree.

At certain neutron energy levels, which vary with the absorbing material, the absorption probability increases sharply—because of the so-called "resonance" absorption (Fig. 1).

Finally, neutrons may be lost because they escape from the reactor without undergoing fission, or "leak." In a practical reactor, the fuel is spread more or less uniformly throughout the core. Neutron leakage depends not only on the amount of fuel but also on the dimensions and geometry of the core. As we have also seen, the various materials af-

fect neutron scattering and absorption (to degrees depending on their temperature). The properties and distribution of the core materials and their relative amounts therefore determine the mean neutron velocity at which the great majority of fissions of fuel nuclei takes place. This speed is the basis on which reactors are called thermal, intermediate, or fast.

For the reactor's critical state, at which the chain reaction first becomes self-sustaining, is characterized by a neutron flux constant in time and a constant rate of fissions. The latter determines the power. Calculations show that one kilowatt represents  $31 \times 10^{12}$  fissions per second. In practice, the critical state is reached by charging a specific amount of nuclear fuel into the core, since this usually is the last remaining variable.

Other conditions being equal, a reactor can function only so long as the amount of unused nuclear fuel remains above the critical level. When

more on next page



it is said an atomic aircraft will burn 500-600 g of nuclear fuel in a flight around the world, this doesn't mean such a flight can be made with merely 500-600 g of fuel aboard. The 500-600 g can be consumed only if they represent just a small portion of the total fuel in the reactor.

In the very best reactors now operating and being built, the "critical weight" of highly efficient nuclear fuel at the end of the operating period is not less than 80 per cent of the weight after initial charge. This means not more than 20 per cent of the initial charge can be consumed in operation.

The critical weight is reduced by any measures that tend to lessen neutron loss. It is lowest when the moderator and heat transfer agent are heavy water, and zirconium is the structural material.

However, these materials can't always be used. To get high operating temperatures, it sometimes is necessary to use fused metals as the heat transfer agent and heat-resistant nickel alloys as structural materials. Since these materials have high neutron-absorbing properties, less of them must be used within the core to lower the critical fuel weight.

This critical weight can also be reduced by reflection of escaping neutrons back into the core. For this, a scattering substance surrounding the core is used.

Heavy water is the best reflector material. Graphite, beryllium, ordinary water, and zirconium follow in order of diminishing effectiveness. As the thickness of the reflector increases, so does the number of reflected neutrons. The sharpest increase is produced by the layers closest to the core (Fig. 2).

With a reflector, there is an increase in the rate of fission near the core boundary. Efficient use of this peripheral zone enables the designer to make the reactor core smaller



ANOTHER REA

THE MARK OF QUALITY



Barber-Colman SYLC Actuator undergoing altitude chamber test

# Aircraft and

**AIR VALVES** — A wide variety of electrically and pneumatically operated air valves for temperature and pressure-control applications. Butterfly, check, poppet, slide, and automatic drain types.

**ACTUATORS** — Rotary and linear types featuring a wide range of gear switching and mounting details. Available either as standard units or special to fit various applications. Designed to applicable military specifications.





**If it's Barber-Colman, it's better**

**designed for precision applications,  
new SYLC actuator meets the most exacting  
specifications on every count**



Indicative of the Barber-Colman ability to build aircraft and missile controls that meet extreme requirements is this special, lightweight SYLC linear actuator. Designed for a high-speed jet fighter elevator trim application, it passes these specifications:

- Servo mode response rate
- Low backlash — less than .005"
- Small differential ball detent clutch (90 lb carry — 110 lb full slip)
- Less than 40 milliseconds' stopping time
- Position indication — .002" resolution
- Ambient temperature range — 65°F to +275°F
- Travel limit and centering switches
- Nonjamming positive stops
- Radio noise filter
- Thermal overload protection
- Weight 3.4 pounds

The Barber-Colman line of compact SYLC linear actuators is designed to handle loads in excess of 150 pounds and withstand 20 G vibration. They feature low backlash and high positioning accuracy . . . optional radio noise filter . . . adjustable limit switches . . . optional centering switches . . . permanent magnet d-c, split-series d-c, or 400 cycle a-c

drive motors . . . dynamic braking and thermal overload protection if desired. For information on use of these actuators on your applications, call the Barber-Colman engineering sales office nearest you: Los Angeles, Seattle, New York, Boston, Baltimore, Fort Worth, Montreal, Rockford, or write direct to address below for literature.

## BARBER-COLMAN COMPANY

Dept. A, 1423 Rock Street, Rockford, Illinois

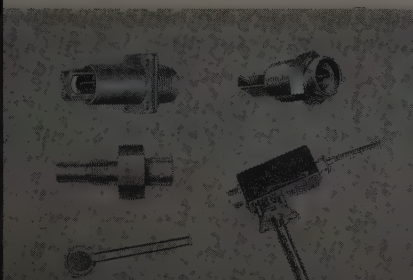
Aircraft Controls • Electrical Components • Small Motors • Automatic Controls • Industrial Instruments • Air Distribution Products • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

# Missile Accessories

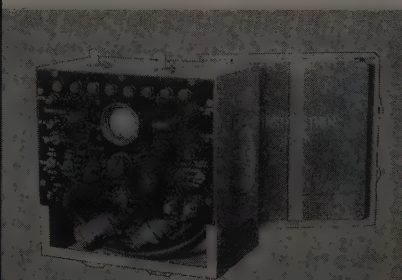
**TEMPERATURE CONTROL AND  
SIGNALING SYSTEMS** — Electronic, mag-  
nifier, transistor, or relay-controlled  
designed to meet your requirements.



**TRANSDUCERS AND  
THERMOSTATS** — Units for sensing  
compartment, duct, windshield tempera-  
tures. CEDAC system senses, controls  
temperature and/or airflow in ducts.



**TEST EQUIPMENT** — Compact electrical  
test units for quickly checking all components  
of a Barber-Colman control system installed  
in an aircraft. Special units for checking  
many electrical systems.



Circle No. 256 on Reader Service Card in Product Review Section

## NUCLEAR ENGINES

than it could be in a reactor without a reflector.

It is true the overall dimensions of a reactor are greater when a reflector is used. But we must not forget that the reflector is an integral part of the shielding. The thicker it is, the less special shielding will be needed.

For high temperature aircraft reactors, graphite is the only cheap reflector material worth considering. The smallest reactor dimensions are possible with reflectors made of beryllium, which melts at 1315 deg C and is inert to neutron irradiation. However, it costs a lot.

A steady state, in which neutron flux and reactor capacity remain constant in time, is observed when the reactor is in the critical state by the fact that the neutron multiplication constant ( $K$ ) equals unity.  $K$  is the ratio of neutrons undergoing fission in a given generation to neutrons that have fissioned in the preceding generation.

If the reactor has more than the critical amount of fuel,  $K$  will exceed unity. A constant increase in power results. A reactor is placed in this "super-critical" state to "race" it. A special case of racing is the starting of the reactor.

**Control possible if  $k_{ex}$   
drops below 0.01**

As an example, let us assume that, in a slow reactor in the critical state, we have suddenly increased  $K$  to 1.1 or introduced an excess reactivity  $k_{ex}$  of 0.1. Calculations show that, at this excess reactivity, the reactor power will increase 2.7 times in 0.002 seconds, 1500 times in 0.01 seconds, and about 20,000 times in 0.02 seconds. A breakdown is almost inevitable.

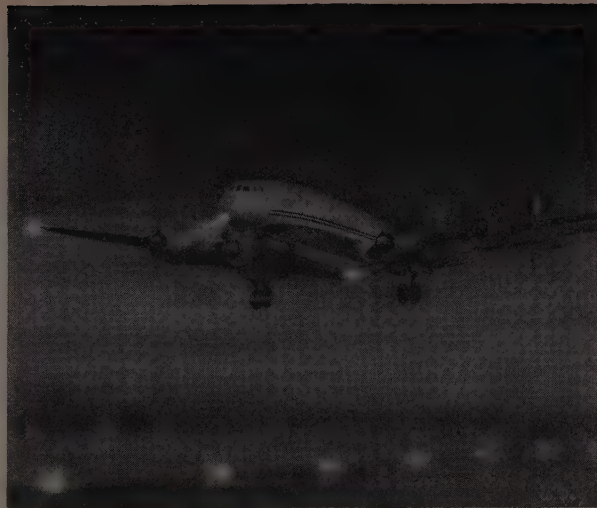
In a fast neutron reactor, power increases about 150,000 times in  $10^{-6}$  seconds at 0.1 excess reactivity. This rate of evolution comes close to that

more on next page





**MISSILE COMPONENTS** Bulova safety and arming systems protect ground, air and sea crews from load to launch, then take over in flight. Safety factor of one in a million is specified and reliably delivered by Bulova's precision production facilities. Powder-driven gyros and fuzing systems are among other Bulova developments for 18 key missiles.



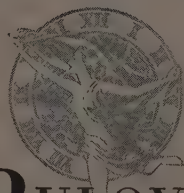
**AIRCRAFT INSTRUMENTS** Bulova's new Servo Altimeter assures maximum reliability through unprecedented sensitivity, accuracy and repeatability. At 40,000 feet, it detects 4-foot changes... is correct to 40 feet. Safety is improved in traffic control and flight over difficult terrain. As a control instrument, it is readily adaptable to guided missiles.

## Bulova reliability helps to solve today's most challenging problems

For more than 80 years, Bulova has charted new courses in the area of reliability.

Milestones along the way are the electronic and electro-mechanical devices created by the Bulova capability—the uncommon blend of pioneering vision and precision production experience.

These Bulova developments, distinguished



**BULOVA**  
watch company

BULOVA RESEARCH AND DEVELOPMENT LABORATORIES, INC.

by their advanced design and consistent high performance, help our nation's defense and industry stake solid claims on the frontiers of science and space.

The high degree of Bulova reliability prevails from concept to mass production. For assistance with your systems and components problems, write: *Department G.I.S. 3, Bulova Park, Jackson Heights, New York.*



**INFRA-RED COMPONENTS** Bulova infra-red cells are designed to unerringly guide Sidewinders to target. Bulova-improved production processes increase yield and product reliability. Other infra-red developments include filters, reticles and thermistor bolometers, as well as advanced research in mosaic and lead selenide cells.



**PHOTOGRAPHIC SYSTEMS** Bulova's new high performance 70mm recon-camera features 8 frame/sec. and pulse operation... vibration-free exposures to 1/4000 sec. From the smallest 16mm gun camera ever built to units of 9x18" format size, Bulova developments include optical, data recording and instrumentation, and special sequence cameras.

### NUCLEAR ENGINES . . .

of an atomic explosion.

Even at an excess reactivity of 0.01 it still isn't possible to control a nuclear reactor. As soon as  $k_{ex}$  drops below 0.01, though, the picture changes sharply. The reason is that during the very brief time required for fission, only 99 per cent of the number of neutrons escape. The remaining "delayed" neutrons appear in groups with a delay of up to 80 seconds. They are emitted in "fragments" of the fissioned nuclei as these undergo radioactive decay.

The exact percentage of delayed neutrons is 0.755. Therefore, to guarantee safe operation during start,  $k_{ex}$  must be less than 0.00755. About 0.005-0.006 is recommended. In this  $k_{ex}$  range a slow reactor will need about six seconds to increase its power 2.7 times and 30 seconds to increase it 500 times.

Power increases in a fast reactor takes place at about the same rate, which insures reliable regulation of a chain reaction. Power reduction in practice also depends on delayed neutrons (Fig. 3).

Reactivity can be changed for control purposes (either manually or automatically). One way of doing this is to shift the control rod.

When the rod is pushed into the core, neutron absorption increases and reactivity decreases. If the reactor was in a critical state, it will now become subcritical. Withdrawal of the rod will increase the reactivity again.

Spontaneous changes in reactivity occur when the temperature is changed. An increase in temperature usually decreases the reactivity—all materials become less dense as they are overheated, and the greater distance between their nuclei means fewer of these will collide with the neutrons. This relationship between reactivity and temperature makes it easier to control the reactor.—End



This Unit Is Worth  
**ONE BILLION DOLLARS**  
 in equipment it will save



600 GPM Jeep-mounted PERMA-DRY Fuel-Water Separator.

## **PERMA-DRY**... *The only proven unit for JP or RP fuel-water separation*

Developed for the missile, jet and rocket program and proven by rigid Air Force and Government tests, PERMA-DRY exceeds Government specifications (600 GPM).

The PERMA-DRY Fuel-Water Separator will break an emulsion from any fuel and deliver it 10 to 15 PPM below the saturation point and sub-micronically clean.

Designed for highest dependability, the PERMA-DRY has been tested successfully more times and in more places than any other separator. Utilizing inexpensive elements, PERMA-DRY is easy to use and maintain. It is available in sizes from 5 to 1500 GPM in either mobile or stationary mountings. Dirt-holding capacity more than double that called for in military specifications insures longer life between servicings of the PERMA-DRY Unit.

Now, the use of a PERMA-DRY unit will assure you of absolute jet fuel reliability . . . give safe, high-speed

refueling. PERMA-DRY eliminates "flame-outs" caused by contaminated fuel.

If your present equipment is of the old type, phone or wire the PERMANENT FILTER CORPORATION . . . the world's foremost rocket, missile and aircraft filter manufacturer.

*Reliability is the reason why Permanent Filter Corporation's sales have doubled every year for the past seven years. Over 500 field-tested models of airborne and ground support PERMANENT FILTERS are now being used in more than 100,000 missiles, rockets, and supersonic aircraft.*

A few distributor areas are still open for the world's fastest-growing sales organization.

## **PERMANENT FILTER CORPORATION**

Address Department SA4, Permanent Filter Corporation, 1800 W. Washington Boulevard, Los Angeles 7, California, for additional information regarding specific filtration requirements you might have. Detailed recommendations furnished on request.







## Dark or light, fair or foul... **ABLE** finds True North fast

Aline your missile-launchers and your mobile radars fast—with celestial accuracy—any weather, any time of day. Do it with ABLE, Autonetics' Base Line Equipment. ABLE is a portable field instrument designed to find True North or any other base line—automatically. ABLE is reliable, easy to operate and maintain.

Please write for literature. **Autonetics**



A Division of North American Aviation, Inc., Downey, California

## Ceramo® Thermocouple Wire Meets Severe Conditions

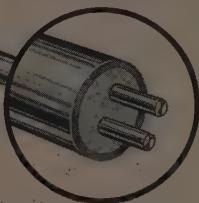
Where Durability, Hi-Temp Resistance Are Needed

Ceramo® thermocouple and thermocouple extension wires are designed specifically for severe conditions—conditions where ordinary T/C wires are inadequate. First developed by Thermo Electric, "Ceramo" wires incorporate ceramic insulation with over-all metal sheathing. They'll solve your problems of high temperature, abrasion, chemical or corrosive action, pressure and difficult installation. You can bend them to almost any shape. As extensions, you can often use them without conduit. And under these conditions they'll outlast comparable standard types many times—with no significant difference in response. Choice of conductors in all standard calibrations and various sheath materials for temperatures up to 3000°F. Conductors—36 to 12 gage. Overall diameters—1/25" to 7/16" for thermocouples; 1/8" and 1/4" for extensions.

Write for Bulletin No. 31-300-A

**Thermo Electric Co., Inc.**  
SADDLE BROOK, NEW JERSEY

In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.



## Aircraft•Missile Electronics

### Production Engineering



TYPICAL setup of electric discharge machine.

## Microinch tolerances with electric discharge machining

Many of the newer temperature resistant, hard metals that practically defy conventional machining can be handled by electric discharge methods. This process holds surface finishes to 10-20 in.—without scratches, heat checks, waviness, or chatter—and drill holes and cavities to 0.0005 in.

by **W. F. Wagner**

Supervisor, Design Producibility & Standards, Northrop Aircraft, Inc.\*

**E**LECTRIC discharge machining is similar to electrolytic and ultrasonic machining—all three methods erode the work piece. But there the similarity ends.

The electric discharge meth-

od uses an intermittent high frequency spark to remove the material by erosion. Both the electrode and the work piece must be submerged in a non-conductive or dielectric fluid.

Electric discharge machining is done by a series of discharges that occur at a rate of 20,300,000 per second. With each buildup of voltage, electrons pile up on the surface of the electrode until the stress becomes so high that they break through the surface barrier and speed toward the work piece.

The collision of these electrons with atoms on the surface of the work piece leave the atoms minus an electron, or with a net positive charge.

\*Northrop Aircraft, Inc., 1001 E. Broadway, Hawthorne, Calif. This is a condensation of a paper, "Electrical Discharge Machining," presented at the SAE Aircraft Production Forum in Los Angeles last Sept. 29-30.



## Erosion of Brass Electrodes

Material Group	Relative Erosion Rate	
	Tool	Work
Tungsten	3	1
Carbides	3	1
Aluminum	3/4	1
Stainless steel	1	1
Aluminum	1	1
Copper, bronze, & brass	1/2	1
Aluminum & soft metals	1	15

This turns a tiny portion of the work piece into superheated metallic vapor carrying a positive charge.

Since dissimilar charges are drawn to one another, the positively charged particle from the work piece is attracted to the negative electrode, or tool. As the particles begin to move, they are cooled by the dielectric fluid before they reach the electrode and are washed out of the gap.

Theoretically, none of the particles ever reaches the electrode, and the electrode does not erode. Unfortunately, this is not true. Mainly because of imperfect flushing, a small percentage of the particles does reach and erode the electrode.

A variety of precise electric discharge tools (electrodes) are available today for drilling, die sinking, forming of irregular internal shapes, and tool and surface grinding. A considerable amount of repetitive die sinking is being done economically with Elo-Met as the tool, or electrode material.

Elo-Met is a 50-50 tin-zinc alloy and melts at 640 deg F. In the die sinking application, it is cast into a machined prototype die. After cooling, the casting is squeezed back into the die under pressure to overcome shrinkage.

These castings may be acid-etched to any degree of under-size to produce roughing and finishing electrodes. In some cases, the useful life of the

more on next page



# sophisticated

## mission training

THE F-105-D FLIGHT SIMULATOR— BEING  
HUMAN ENGINEERED, DESIGNED AND  
BUILT BY ERCO PROVIDES COMPLETE, RELIABLE,  
EFFECTIVE TRAINING  
FOR THE ENTIRE MISSION PROFILE OF  
THE LATEST AIR FORCE  
ADVERSE WEATHER AIRCRAFT.

### FEATURES

- Automatic Self-Checking System (aural-optical) provides component failure indication by general area and exact location. The simulator is operative in a matter of minutes.
- Reliability—in excess of 95% utilization.
- Human Engineering—complete environmental realism.
- Man-Machine Task Analysis Design—maximum learning transfer for both operator and instructor.
- Erco's man power—facilities—capabilities and mission training experience help the Air Force "to fill the suit...to man the plane."

WRITE FOR ILLUSTRATED F-105-D MISSION TRAINING BROCHURE.



ERCO TRAINING TO FILL THE SUIT...TO MAN THE PLANE

# ERCO

NUCLEAR PRODUCTS—ERCO, DIVISION OF  
QCF INDUSTRIES, INC., RIVERDALE, MARYLAND

AMERICAN CAR AND FOUNDRY • ADVANCED PRODUCTS • AVION • CARTER CARBURETOR • SHIPPERS CAR LINE • W-K-M

Circle No. 260 on Reader Service Card in Product Review Section

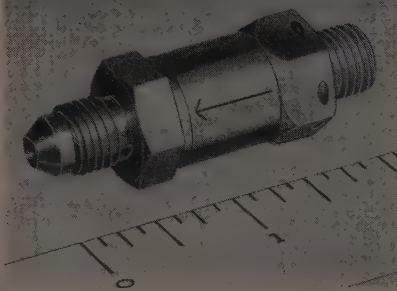


## Precision Pressure and Flow Control Valves

designed and manufactured to customers' specifications

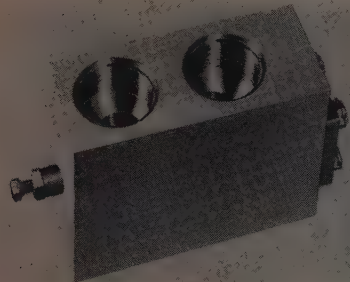
### Thermal Relief Valve

- Zero leakage — internal and external
- Small size, lightweight (under 1 oz.)
- Accurate pressure response
- Cracking pressure — available in 20 to 60 psi range



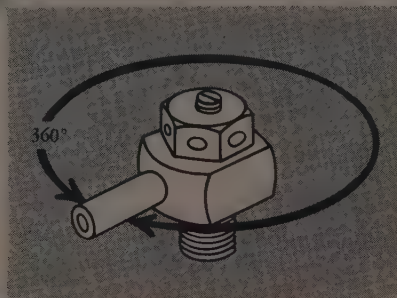
### Controllable Check Valve

- Requires low mechanical force to unload—100 lbs. max. at 3000 psi.
- Internal leakage — drops/hr (lapped steel seat)
- Low pressure drop — both directions
- Ports — AND-10050-16



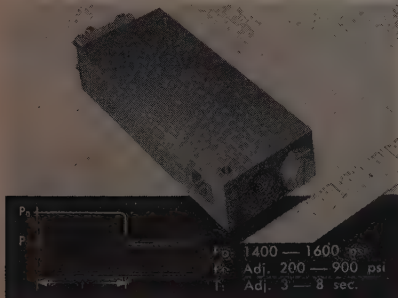
### Bleeder Valve

- Reduces fire hazard
- System may be bled while under pressure
- Confines and directs discharge
- Burst pressure — over 14,000 psi.



### Automatic, Hydraulic Pressure Dropping — Time Delay Valve

- Combines functions of six valves in single body
- Simplifies system design
- Reduces installation costs



### TYPICAL VALVES

- |   |                                    |
|---|------------------------------------|
| Flow Regulators                                     | Controllable Checks                |
| Flow Dividers                                       | Relief Valves—All Four Basic Types |
| Sequence Valves                                     | Restrictors                        |
| Selector Valves                                     | Special Non-standard Types         |
| Check Valves  |                                    |
| Pilot Checks  |                                    |
| Combinations of Two or More Types in a Single Body. |                                    |

Fluid Regulators' wide range of custom engineered components is proof of their ability to design and manufacture the exact valves you need to meet your requirements. Each valve is individually tested.

**Fluid Regulators**  
CORPORATION

313 GILLETTE ST. • PAINESVILLE, OHIO • ELwood 2-3319

Circle No. 261 on Reader Service Card in Product Review Section

## DISCHARGE MACHINE . . .



VARIETY of tools or electrodes used in electric discharge machining is limited only by the user's ingenuity.

**SURFACE FINISHES** on carbide cutting tools produced by electric discharge machining (left) and conventional machining.



tool reportedly was extended nearly fifty fold by etching undersize and then building back up to the desired size with hard chrome plating.

Some work has also been done on the contouring of large honeycomb sections whose cover skin is drawn into a contoured female electrode. In this case, the skin itself is used as the tool, or electrode, to shape the honeycomb core. Matching the skin and the core produces a good, close fit for bonding and brazing.

Electrodes, or tools, can be made from a variety of materials—yellow brass, copper tungsten, silver tungsten, tungsten carbide, carbon, Elo-Met, etc. It all depends on the ap-

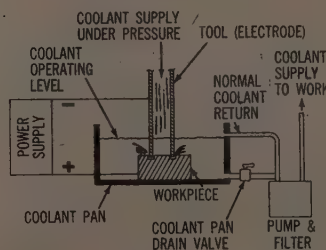
plication and material to be machined. The most commonly used materials are yellow brass and Elo-Met.

Electric discharge machining is particularly well suited to producing holes and cavities to tolerances of  $\pm 0.0005$  in. Virtually no heat is generated in the work piece, so that it is possible to drill precise holes spaced no more than 0.005 in. apart without any distortion or mutilation of the remaining web. Holes as small as 0.002 in. in diameter have been drilled through  $\frac{3}{8}$ -in.-thick steel plate.

Electric discharge grinding techniques are used for surface finishing and machining. The "grinding" wheel is usually made of free machining brass but contains no abrasives whatever and never touches the work.

The wheel is rotated at 100-200 rpm and maintained at a fixed gap distance from the work piece by a servo unit. The metal is removed by the action of the high frequency discharge.

This method has many advantages over conventional abrasive grinding. It is possible



BASIC arrangement of elements in electric discharge machining.



get a 10-20-uin. mat surface finish without any heat checks or feather edges. As the wheel never touches the work, there is no mechanical pressure or spindle vibration. This virtually eliminates all waviness and chatter.

Cuts of any width or depth (limited only by wheel size) are possible in a single pass, there is no need to reciprocate the wheel or work piece.

The cost of electric discharge grinding of otherwise expensive carbide form tools is in many cases only 35 per cent that of conventional grinding. On top of that, the finished tools can be operated at appreciably higher feeds and speeds than conventionally ground carbide tools, produce smoother surface finishes, and have 4½ times longer service lives between grinds.—End

The further we progress,  
the more important  
experience becomes in solving  
today's most urgent problems.



One company actively and continuously engaged in advanced ECM research and development since 1952 is ...

**hallicrafters**

4401 W. Fifth Ave., Chicago 24, Ill.

- SERVICES**—research and development  
• electronic equipment production  
• reliability evaluation
- EQUIPMENTS**—communications • radar  
• countermeasures • reconnaissance  
• infra red devices • heat exchangers  
• pulse generators • antennas

## 4 Ounce Contact Force Gives Relay Reliability

Contact force of 4 ounces per contact on 50 "G" models and 2 ounces per contact on 30 "G" models of "Diamond H" Series R and Series S miniature, hermetically sealed, aircraft type relays is one of the most important factors in their proven high reliability.

Though absolute reliability of any similar device is impossible to guarantee—a bitter fact of life recognized by all electronic engineers—close approach to this goal by the relays manufactured by

The Hart Manufacturing Company is the basic reason they are found today on many of this country's headline-making missiles.

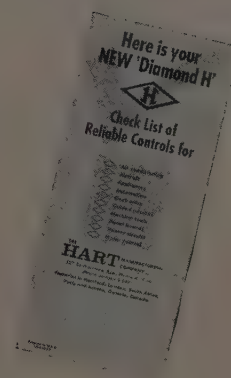
In addition to contact force far beyond that found on other relays, "Diamond H" relays have greater contact cleanliness. Self-contamination is virtually eliminated by a completely inorganic switch mechanism, as well as use of coil materials which will not dust, flake or out-gas.

Finally, the high degree of reliability that is designed into these relays is maintained in their manufacture by high quality workmanship and a stringent inspection policy at every stage.

In addition to missiles, and their ground control systems, Series R and S relays are designed for use in jet engine controls, computers, fire control, radar and similar critical applications.

4PDT units, they offer an extremely broad range of performance characteristics, including temperature ranges from —65° C. to 125° and 200° C.; ratings to 10 A., 120 V., A. C., and 26½ V., D. C., with special ratings to 400 ma. at 350 V., D. C., or down to millivolts and milliamperes. Dry and wet circuits may be safely intermixed.

For more information, write today for Bulletins R250 and S260. For quick facts about "Diamond H" switches, thermostats and other devices, ask also for a copy of the "Diamond H" Check List of Reliable Controls.



THE **HART** MANUFACTURING COMPANY

212 Bartholomew Ave., Hartford 1, Conn.  
Phone JACKson 5-3491



# Bendix-Montrose

## INTEGRALLY LIGHTED INDICATORS



2 INCH SINGLE

2 INCH DUAL



ANGLE OF ATTACK

1 INCH SINGLE

These instruments are integrally lighted in accordance with MIL-L-25467A. Also available in a variety of pressure ranges and position indications. Special functions on request. Instruments meet all applicable MILITARY SPECIFICATIONS.

### OTHER BENDIX-MONTROSE COMPONENTS:

Pressure Transmitters  
Position Transmitters  
Warning Switches

Dynamotors  
Ordnance-type Synchros  
D. C. Motors

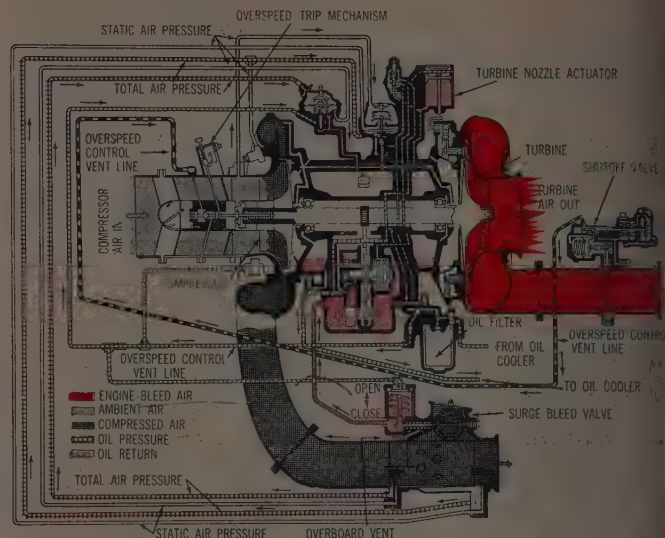
West Coast Sales and Service Office, 117 East Providencia Avenue, Burbank, California  
Canadian Affiliate—Aviation Electric Limited, 200 Laurentian Blvd., Montreal, Quebec  
Export Sales and Service—Bendix International Division, 205 East 42nd Street, New York 17, New York

**Montrose Division**  
South Montrose, Pa.



## Aircraft•Missile Engineering

### Accessory Systems



**FIGURE 1:** Operational flow diagram of turbo compressor. Besides speed controls, safety features include: overpressure shutdown on shutoff valve to preclude effects of pressure regulator malfunction, variable-area nozzles aerodynamically loaded to fail closed, hydraulic nozzle actuator spring-loaded to fail closed.

## Cabin pressurization now needs built-in reliability

As production runs become shorter and planes more expensive, systems reliability no longer can be built around failure feedback from testing—it has to be built in right from the beginning. Here is an outline of what this means for cabin pressurization design.

**by Carl W. Jonasson**  
Group Engineer, Mechanical  
Engineering Staff, Transport Div.,  
Boeing Airplane Co.\*

**RELIABLE** cabin pressurization is becoming ever more important as the industry makes the transition to jet transports in the commercial

field and to spacecraft in the military. USAF's Lt. Gen. C. S. Irvine recently stated the case for reliability: "In the past, we have used such techniques as failure-feedback reportings in reliability and durability. These procedures worked fairly well with long production runs.

"In the future, however, when short production runs will be the norm, backtrack corrections will be totally unacceptable. This means that full time, maximum performance capabilities must be de-

\*Transport Div., Boeing Airplane Co., Renton, Wash. This is a condensation of a paper, "Standard for and Reliability of Cabin Pressurization Equipment," presented at the USAF-Industry Symposium on Aircraft Pressurization & Oxygen Systems, last Sept. 23-24, in Los Angeles.



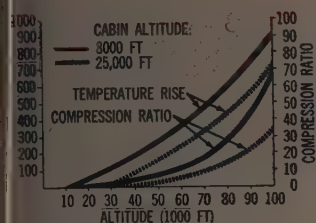
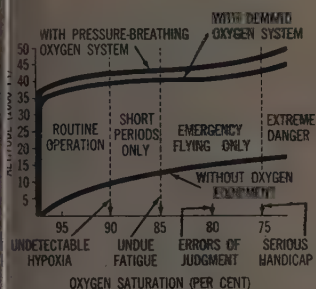


FIGURE 2: Cabin pressurization penalty as variation of temperature rise and compression ratio with altitude.



HUMAN reaction to altitude with supplemental oxygen. (Hypoxia is loss of useful consciousness because of crease in partial pressure of oxygen with exposure to increasing altitude.)

designed, developed, and produced into first and subsequent items. . . . Functional reliability and structural durability should be virtually 100 per cent."

Cabin pressurization systems can be generally divided as in Figure 3. Up to 50-60,000 ft altitude, the external air supply system with outflow pressure control is the most logical choice. In this range, the cost of pressurizing ambient air isn't excessive. A system providing a fresh air ventilating rate high enough so no air must be recirculated will normally provide air in excess of that required to make up for structural leakage.

As Figure 2 shows, the air-plane penalty for pressurize ambient air increases very rapidly at 40,-100,000 ft. It's log-

more on next page



*No matter what you make...*

look to these two general purpose steels to standardize, simplify, and save money!

#### 4340 THROUGH-HARDENING

4340 stands alone among medium carbon steels in its ability to provide maximum strength, ductility, toughness and resistance to fatigue in parts of medium to heavy cross section.

#### 4620 CARBURIZING

4620 is a carburizing type that has consistently proved itself the ideal steel for a wide variety of carburized parts. 4620 is easy to carburize and has a minimum tendency toward distortion in heat treatment.



*Easy to Get . . . Both these steels are carried by many Steel Service Centers from coast to coast . . . ready for delivery on a "next door" basis. For a list of names and addresses of Steel Service Centers that carry AISI 4340 and 4620, write us.*

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street

New York 5, N.Y.



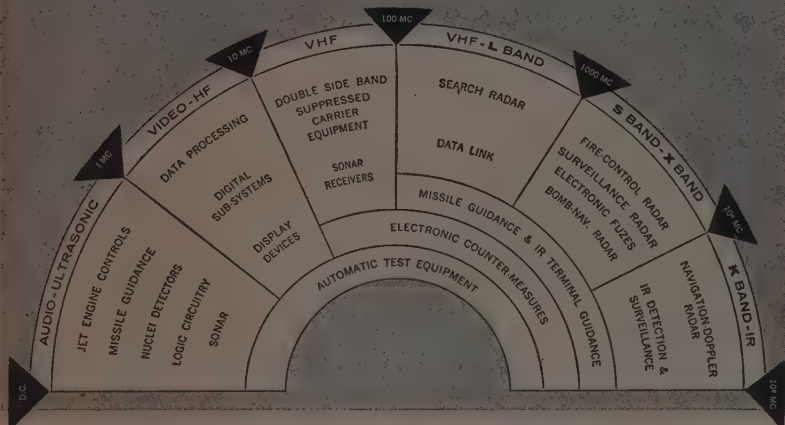
Circle No. 265 on Reader Service Card in Product Review Section



Engineers-EE, ME, Physicists

# PROFESSIONAL CHALLENGE AWAITS YOU AT ANY POINT ALONG THE RF SPECTRUM

At General Electric's Light Military Electronics Department



By designing across the entire electromagnetic spectrum, Light Military displays diversification that is unique in the industry.

It takes a versatile engineer to answer the challenge projected by this type of diversity—one who can move freely across his discipline, exposing himself to unfamiliar problems and exploring new ideas with colleagues in the advanced

areas of electronics.

But equally important, Light Military's diversity demonstrates a characteristic of high significance to engineers seeking long-term futures—*stability*.

A unique combination of these two factors—diversity and stability—provides the formula for unusually rewarding careers at Light Military Electronics Department.

*We are particularly interested in talking to people capable of circuit design and systems analysis in the following fields:*

**POLARIS MISSILE GUIDANCE — ELECTRONIC COUNTERMEASURES PROGRAMS — SURVEILLANCE & FIRE CONTROL RADAR — DIGITAL TECHNIQUES — DISPLAY DEVICES — NAVIGATION EQUIPMENTS — MICROWAVE DEVICES — TRANSISTOR TECHNIQUES — RELIABILITY**

*Also Mechanical Engineers interested in the following fields:*

**ELECTRONIC PACKAGING — SHOCK & VIBRATION — EQUIPMENT CONFIGURATION — HEAT TRANSFER — MECHANISMS**

*Also openings in ADMINISTRATIVE ENGINEERING — TECHNICAL WRITING*



## GENERAL ELECTRIC

Forward your resume in confidence, or simply fill out and mail this coupon.

Mr. Richard C. Kimm  
General Electric Company  
Light Military Electronics Department  
French Road, Utica, N. Y.

I am interested in professional career opportunities at Light Military.

Name \_\_\_\_\_

Home Address \_\_\_\_\_

City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

Phone \_\_\_\_\_ Degree (s) \_\_\_\_\_

Year (s) Received \_\_\_\_\_ I am particularly interested in the following

technical areas: \_\_\_\_\_

(U. S. citizenship required)

15-MA

## CABIN PRESSURIZATION . . .

### Reliability Comparison of Component Arrangements

Number of Identical Components	Series		Parallel	
	System Reliability	Flights Without Failure	System Reliability	Flights Without Failure
1	0.9	10	0.9	10
2	0.81	5.26	0.99	100
3	0.729	3.69	0.999	1000
4	0.6561	2.91	0.9999	10,000
5	0.59049	2.50	0.99999	100,000

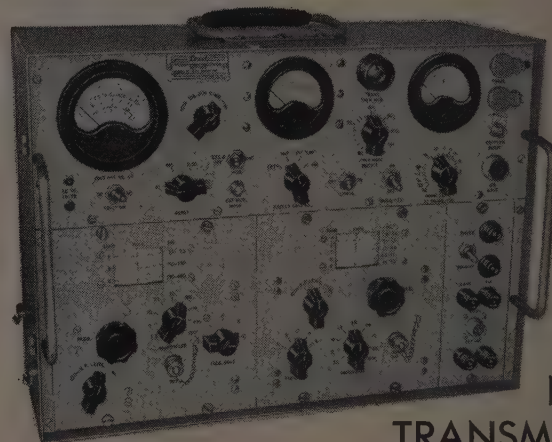
ical to supply only enough ambient air to maintain the desired pressure in the cabin. This system will have inflow pressure control. Recirculation of cabin air will then be needed to provide proper air velocity, temperature, and humidity control.

As we approach 100,000 ft, a careful study of all the penalties imposed on the vehicle by the cabin pressurization system

may show that the best compromise would be a combined system. Here the cabin air would be enriched with oxygen, so less pressure would be needed for adequate physiological protection. This extends the altitude for which external air can be used. Ram pressurization would also become more feasible.

Above the altitudes where it's no longer practical to pres-

## PRE-FLIGHT RADIO TESTER



RT-500

### TRANSMITTER- RECEIVER TEST SET

The RT-500 tests — IN PLACE — the performance of ALL aircraft and vehicular communications equipment in the 190 kc — 400 mc frequency range. The functions of Transmitter Monitor, AC-DC Voltmeter, Milliwatt Meter and two wide-range Signal Generators are combined in one compact, easily transportable, precision instrument.

All necessary couplers, cabling, adapters and accessories are included. The interconnecting cable is sufficiently long (3 ft.) to allow the RT-500 to remain in the service vehicle while making tests. High accuracy, rugged reliability and maximum stability are featured in this laboratory quality, portable instrument.

Write for details and specifications

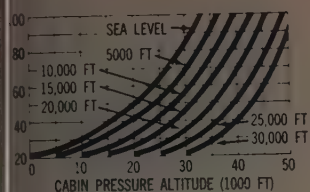
## TRAD ELECTRONICS CORPORATION • ASBURY PARK, N. J.

Circle No. 267 on Reader Service Card in Product Review Section

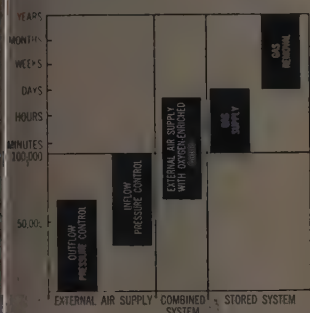
SPACE/AERONAUTICS

Circle No. 266 on Reader Service Card opposite last page or send personal resume direct to address mentioned above. GIVE HOME ADDRESS





**OXYGEN** concentration vs cabin pressure altitude.



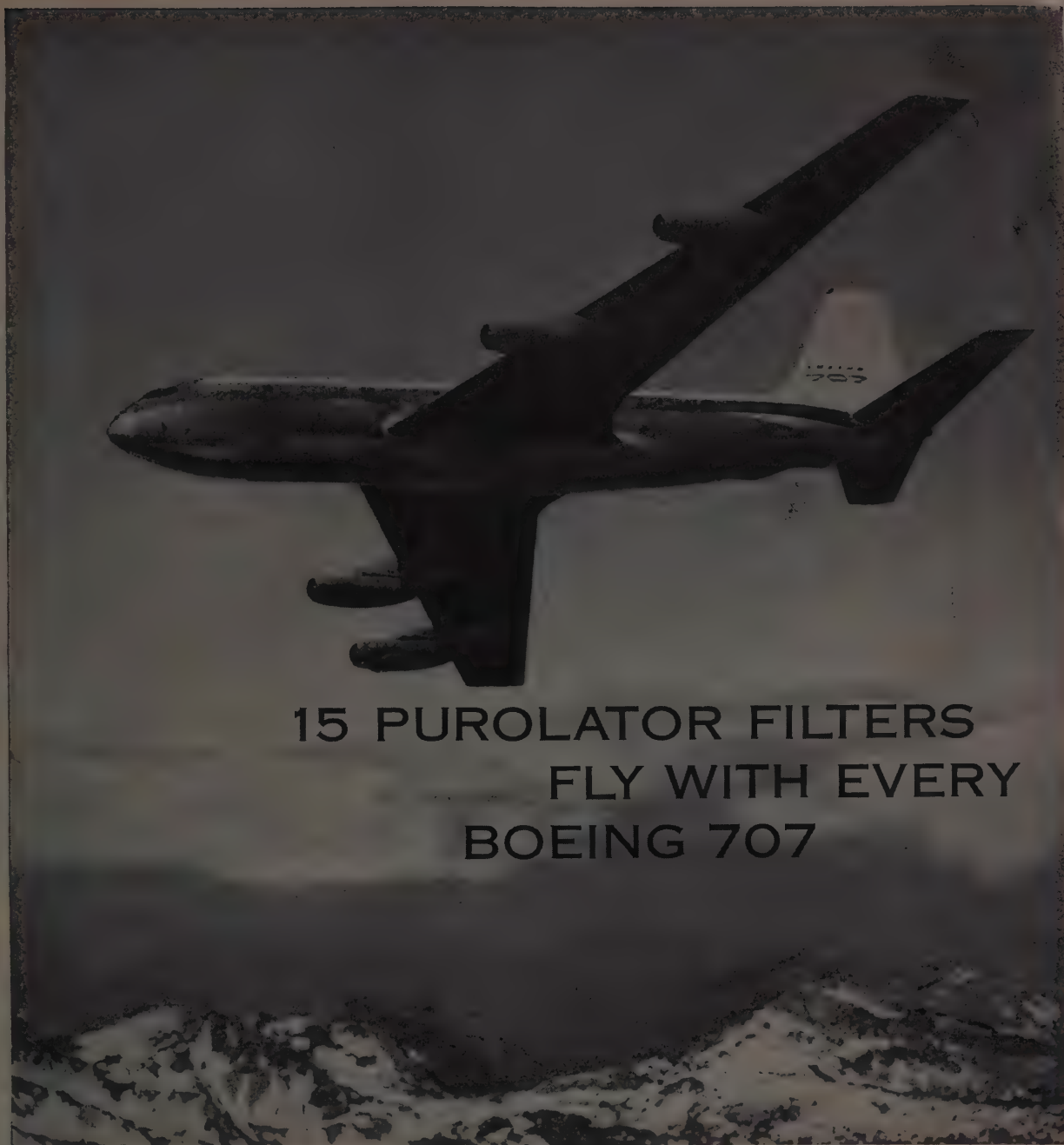
**FIGURE 3:** Basic categories of cabin pressurization systems.

urize ambient air, a stored system, using liquid gas, or the like, is required. For flights limited to several hours' cruise at these altitudes, only a semi-sealed cabin is needed. After the gas has been used to cool the cabin, remove  $\text{CO}_2$ , water vapor, and odors, it will be discharged overboard. The rate at which the gas will be used is a function of cabin pressure, and temperature, and minimum ventilation. The best system would be one in which the leakage rate at full pressure about equals that required for cooling during cruise conditions.

For the longer orbital and space flights, the vehicle must be self-sufficient. This will require a hermetically sealed cabin with provisions for controlling pressure, oxygen content, temperature, humidity,  $\text{CO}_2$ , and odor. Rejuvenation of the atmosphere and re-use of human waste products will be essential. The overall reliability must be extremely high.

The reliability of a system is a combination of the reliabilities of the system compo-

more on next page



## 15 PUROLATOR FILTERS FLY WITH EVERY BOEING 707

The Boeing 707 is America's first jet transport. Performance is so outstanding that 11 airlines already have ordered 707's.

Effective filtration is essential on the 707 just as it has been on all aircraft for the past 25 years. Fifteen Purolator Micronic filters ensure that fluids move freely, and give optimum performance, by filtering out sub-micronic particles of foreign matter . . . particles that could cause serious trouble in a jet transport going 600 miles an hour.

With filtration such a must in any aircraft built today . . . or planned for tomorrow . . . there's no reason to settle for anything less than Purolator.

For every vital fluid used in aircraft . . . fuels, lubricants, hydraulic fluids and air . . . nothing performs better than a standard Purolator filter. The same will hold true when new needs arise. All fluids need filtration. And none need get along without the extra margin of reliability of Purolator filtration.

*Filtration for Every Known Fluid*

**PUROLATOR**  
PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

Circle No. 268 on Reader Service Card in Product Review Section



new missile test panels  
feature

**EMCOR**  
PACKAGING  
FLEXIBILITY



Test panels designed and instrumented by test equipment engineers and builders of Lear, Inc., Grand Rapids, Michigan, assure reliability standards of the Lear Stable Platform being used in the initial guidance system of Boeing's long-range IM-99 Bomarc missile. The test panels feature the flexibility of EMCOR's most modern concept in metal cabinetry... THE EMCOR MODULAR ENCLOSURE SYSTEM. Of uniform size, the test panel frames can easily be bolted, unbolted and rearranged to quickly meet changing production demands. EMCOR's engineering mastery of the design in metal cabinetry makes possible the arrangement of groups of intricately wired instruments, indicators, dials and electronic scopes for easy visual and manual operation while reducing environmental fatigue and strain.

\*Registered Trademark of Elgin Metalformers Corporation

Your copy of Catalog 105 is available upon request.



**ELGIN METALFORMERS CORPORATION**

630 CONGDON, DEPT. 1228  
ELGIN, ILLINOIS

Circle No. 269 on Reader Service Card in Product Review Section

## CABIN PRESSURIZATION . . .

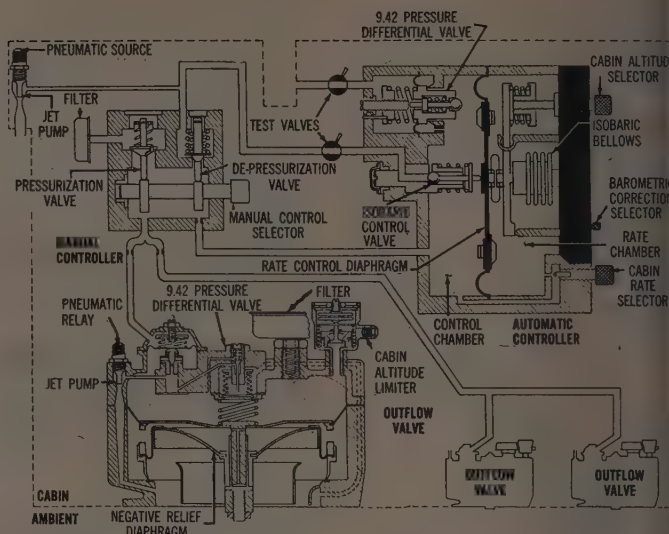


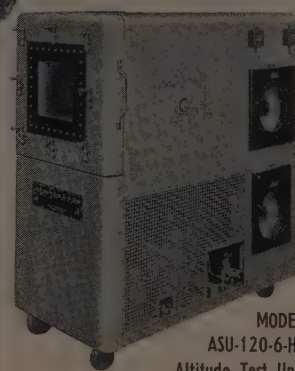
FIGURE 4: Cabin pressurization system for current jet transports.

nents. These component reliabilities can combine in series —when any component fails, the system fails. They can also combine in parallel, so that,

if one component fails, another can perform its function. As the Table shows, the overall systems reliability is greater with components in parallel.

can the metal "take it

Cincinnati Sub-Zero Environmental  
Test Units Provide  
the Answer!



MODEL  
ASU-120-6-HC  
Altitude Test Unit

New 6 cu. ft. model has a temperature range of plus 300 to minus 100° F. Equipped with temperature and altitude recording controllers. Altitude range at sea level to 90,000 feet.

Supersonic speeds . . . rapid atmospheric changes . . . all challenge the structure and components of aircraft, rockets and missiles. "Can the metal take it?" must be answered in advance.

Cincinnati Sub-Zero Environmental Test Units are custom-designed for complete test programs under conditions of high-low temperatures, various altitudes, etc.

Outline your testing requirements today, large or small for a prompt no-obligation recommendation and a copy of the new Catalog.

**Cincinnati Sub-Zero Products**

General Offices and Plant:

3930 V-9 READING RD., CINCINNATI 29, OHIO

Member Environmental Equipment Institute

Circle No. 270 on Reader Service Card in Product Review Section

SPACE/AERONAUTICS



*high reliability... extreme compactness...*

IN THE

NEW SANBORN

850

6- & 8-CHANNEL DIRECT WRITING SYSTEM

The chief factors to be considered for overall reliability are: human reliability, penalty of the vehicle, effect of other systems, mechanical reliability, and emergency provisions.

If human limitations are exceeded because of conditions created by the cabin pressurization system, the decrease in reliability is chargeable to that system. These limitations aren't ways exceeded because of mechanical failures, but sometimes occur because of improper design objectives or improper operating procedures.

Many human errors that may crop up in servicing, maintenance, and operation could be compensated for the original design through good human engineering. For instance, built-in connections in the system can eliminate many servicing mistakes. Designing equipment so it can't be misused can prevent operating errors.

Excessive penalty to the vehicle in the form of extra weight, volume, drag, or power needs can reduce reliability. Since these penalties normally crop up in efforts to gain durability, a compromise must be made for optimum reliability.

Cabin pressurization, or the lack of it, can reduce the overall reliability of the vehicle by creating a condition which may cause some other essential equipment to fail. For example, increased arcing and decreased cooling of certain electric or electronic equipment may be the direct result of inefficient pressure.

An emergency provision can be a piece of equipment or an operating procedure. A typical example of the former is the oxygen equipment in some of the new jet transports. If cabin pressure is lost, the system automatically presents oxygen masks to each passenger and provides him with enough oxygen to prevent marked hypoxia.

A typical emergency procedure

more on next page

If you want a practical direct writing system for straightforward recording in the range from DC to 100 cps — such as computer readout, telemetry recording — look what the new Sanborn "850" offers in compactness, reliability and operating convenience. A complete 8-preamplifier module with power supply, plus an 8-channel flush-front recorder package containing power amplifiers and power supply at rear, occupy only 24½" of "850" panel space.

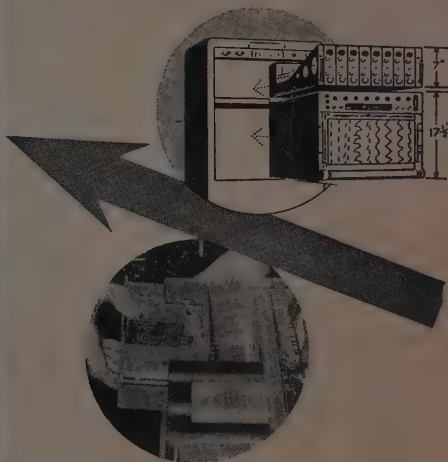
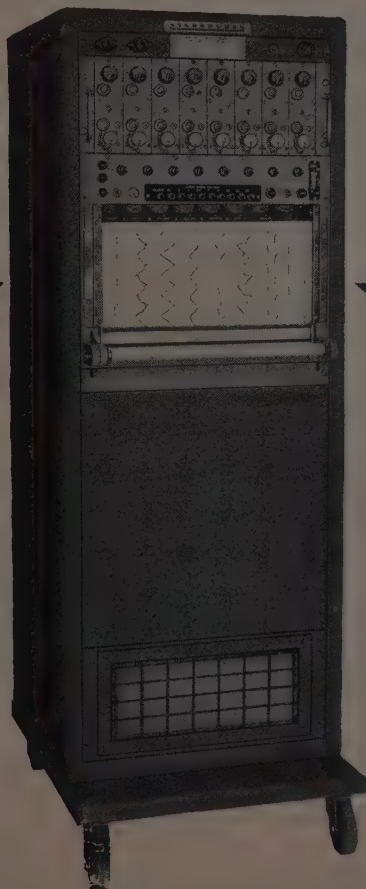
**PERFORMANCE** characteristics of an "850" include flat frequency response 0-70 cps, down 3 db at 100 cps (10 div. peak-to-peak amplitude)... thermal drift eliminated by current feedback power amplifiers... limiting at input to prevent amplifier saturation or cut off, so that damping is never lost... drift less than 0.2 div. for 20° to 40° C. changes, line voltage changes from 103 to 127 volts... gain stability better than 1% with 20° C. and 20 volt changes... linearity 0.2 div. over 50 divisions... clear, permanent, inkless recordings in true rectangular coordinates.

**IN RELIABILITY**, "850" features include fully transistorized power amplifiers and power supply... rugged galvanometers with low impedance, high current, enclosed coil assemblies and velocity feedback damping... JAN components wherever practical, such as MIL-T-27 hermetically sealed power transformers, MIL-approved electrolytics in power supplies, etc... forced filtered air cooling for stable operation.

And in operating **CONVENIENCE**, an "850" system provides such advantages as nine electrically controlled chart speeds, selected by pushbuttons... a choice of interchangeable Preamplifiers (DC Coupling and Phase Sensitive Demodulator presently available, with others in development)... remote control of chart drive, speeds, timer and marker... monitoring connection points... a Recorder that loads from front and has built-in paper take-up and paper footage indicator.

**SANBORN COMPANY**

175 Wyman Street, Waltham 54, Mass.



Ask your local Sanborn Industrial Sales-Engineering Representative for complete facts — or write the Industrial Division in Waltham.

(All data subject to change without notice)

Circle No. 271 on Reader Service Card in Product Review Section



# MicroRold®

stainless steel

soars with

## ATLAS ICBM

on first

full range flight!

*U. S. missile program one step nearer to complete operational capability.*

On the evening of November 28, 1958, a 100-ton ATLAS lifted from its pad at Cape Canaveral and arched majestically into the heavens. 30 minutes later its nose cone shot into the Atlantic, marking the first successful completion of its fully-programmed distance of 6300 statute miles.

The main part of the ATLAS structure is literally a huge fuel tank, the shell of which is thin gauge MicroRold stainless steel. Important factors in selection of stainless steel for the outer skin of the ATLAS are—great strength at both high and low temperatures, resistance to corrosive exotic fuels and good workability.

The stainless skin, supplied exclusively by Washington Steel, requires extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.



**WASHINGTON STEEL CORPORATION**

1-V WOODLAND & GRIFFITH AVENUES

WASHINGTON, PA.

Circle No. 272 on Reader Service Card in Product Review Section

### CABIN PRESSURIZATION . . .

ture is that of descending after loss of cabin pressure. The new jets have high descent rate capabilities to make this maneuver practical at altitudes of 40,000 ft.

Although human beings can generally survive several minutes without oxygen, recovery would be very doubtful following exposure to altitudes over 65,000 ft for more than about 15 seconds. The effects of gas expansion, boiling of body fluids, and lung damage would hinder recovery from hypoxia. Emergency pressure is thus needed. The military probably will use pressure suits. For transports, automatic opening of a ram air scoop as soon as cabin pressure drops to a predetermined value looks promising.

At altitudes at which emergency provisions can no longer sustain life, the aim will be to gain extremely high overall reliability and take the risk of

having a catastrophic failure.

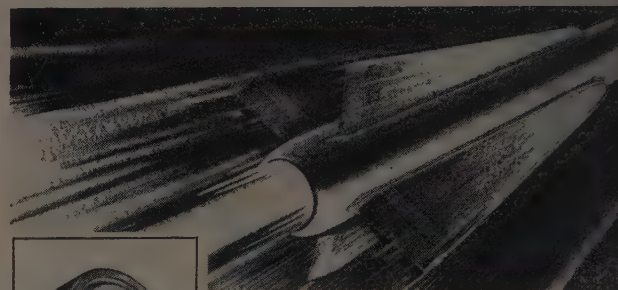
Detail design, of course, can't be ignored. Reliability must be designed into each unit. Examination of current jet transport units shows some of the changes in design thinking that have led to improved reliability.

One example is the turbine compressor. This is basically an air-turbine-driven, single stage compressor with a turbine wheel and a compressor wheel on a common shaft. The air for driving the turbine comes from the aircraft engine. Its quantity is governed by the outflow of the compressor (Fig. 1).

The rotational speeds of the unit are limited to safe values by any of three controls:

- The normal L-control regulates the speed to meet cabin cooling, heating, or pressurization needs and keeps it below 46,500 rpm.

- If the normal control fails



### Minute Giants . . .

B.M.B. Miniature Bearings to the highest precision limits, are made specially for Space craft, missile or ground support instrumentation.

Stainless Steel for servo application, B.M.B. have supplied miniature bearings to the American market for the past ten years.

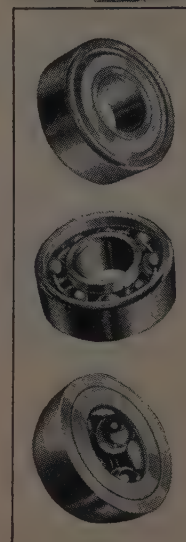
Miniaturization plus reliability equals faultless functioning equals B.M.B. Miniature Bearings.

#### AGENTS:

David R. Grossman Co.,  
155 East 44th Street,  
New York 17, N. Y.  
U. S. A.

Engis Equipment Company,  
431 South Dearborn Street,  
Chicago, Illinois,  
U. S. A.

Manufacturing Associates,  
1416 Westwood Boulevard,  
Los Angeles 24, California,  
U. S. A.



**BRITISH MANUFACTURED BEARINGS CO., LTD.,**

Sole Selling Agents:

B.M.B. Sales Ltd., High Street, Crawley, Sussex, England.

Circle No. 273 on Reader Service Card in Product Review Section



SPACE/AERONAUTICS



mit the speed, a hydraulic  
ing speed control limits  
unit to 47,000 rpm by clos-  
down on the turbine noz-

If the speed continues to  
ease, a trip speed control  
shut down the unit at  
000 rpm. Both the turbine  
off valve and the pressure  
ilating valve go to the  
ed position. The unit can't  
reset in flight.

flow valve design has  
n improved

Figure 4 shows—as part of  
complete pressurization sys-  
n—an outflow valve de-  
ed to today's reliability  
ndards. Its important reli-  
ty features are:

The ambient - pressure-  
sing line is an integral part  
the valve. This reduces the  
bability of failure in the  
as well as the probability  
malfunction due to failure  
connect the line or to con-  
tion to the wrong port.

The pneumatic relays iso-  
e valves that malfunction  
ause of improper control  
nd pressure. In other words,  
component reliability se-  
arrangement has been short-  
ed to increase system re-  
liability.

Jet pumps hold the out-  
w valve open whenever the  
ected cabin altitude is the  
ne as or above the ambient  
tude. This prevents exces-  
e cabin bump when the  
pin air flow is turned on. It  
o allows faster equalization  
cabin and ambient pressure,  
venting a buildup of resid-  
pressure.

A larger cabin vent filter  
duces chances of plugging,  
ich could cause valve mal-  
function.

The cabin altitude limit  
ontrol is designed to make  
re no single component fail-  
e in the pressure control sys-  
n will open the valve and  
pressurize the cabin to an  
ove 15,000 ft.—End

second in a series



## THE MERGER

The legal act of merging two companies into one does not of itself change the sum total of their capabilities. Thus, today the competence of the Ramo-Wooldridge Division for the development of electronic systems for military and commercial applications is indistinguishable from that of its predecessor organization, The Ramo-Wooldridge Corporation, while the skills of the Thompson Products group of divisions in the design and large-scale production of precision devices also remain unchanged. Soon, however, effects of the merger will begin to appear. One early effect will be an important addition of manufacturing strength to Ramo-Wooldridge programs, several of which have passed out of development and are in the prototype or manufacturing phases. Conversely, the special skills of Ramo-Wooldridge scientists and engineers in certain fields can usefully supplement the services that the Thompson Products divisions offer to their customers.

The formation of Thompson Ramo Wooldridge Inc. is intended to provide an unusual capability for the development and production of the complex electronic and mechanical devices and systems required by today's expanding technology.



**Thompson Ramo Wooldridge Inc.**

Main Offices • Cleveland 17, Ohio  
Los Angeles 45, California

## DIVISIONS AND PRODUCTS

**TAPCO:** Missile and aircraft auxiliary power systems, ground support systems, fuel systems, pumps, accessories, hydraulic systems, pneumatic systems; electronic control systems, microwave switches; frame structures, pressure vessels. Jet engine compressor blades, rotors, stators, and impellers; turbine buckets, rotors, and stators; structural and fabricated components. Rocket engine cases, nozzles and pumps. Nuclear reactor control rods, pumps, accessories, and core structures. Precision investment and continuous vacuum cast parts for aircraft, missiles, jet and rocket engines. Vacuum cast super-alloy ingot, billet and mill shapes.

**RAMO-WOOLDRIDGE:** Electronic reconnaissance and countermeasures systems, infrared systems, analog and digital computers, air navigation and traffic control, anti-submarine warfare, electronic language translation, information processing systems, nuclear energy applications, missile electronics systems, advanced radio and wire line communications.

**AUTOMOTIVE AND INDUSTRIAL PRODUCTS:** Valves and associated parts for all types of internal combustion engines. Steering linkages, front wheel suspension ball joints, hydraulic cylinders and pumps, cylinder sleeves, piston rings. Truck retarders. Diesel engine turbochargers. Rock drill bits and drill rods. Alloy pistons for automotive and aircraft; impact extrusions, permanent mold and die castings. A wide variety of automotive replacement parts distributed nationally and overseas through 7,000 distributors.

**CONSUMER PRODUCTS:** High fidelity amplifiers; FM-AM radio tuners; magnetic tape recorders; stereophonic sound systems, public address and intercommunication systems. Television cameras for industrial and broadcast purposes; complete low-power television broadcasting stations.

**THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS CO.:** Digital control computers and associated equipment for automatic control of industrial processes, data logging and computation, pilot plant operation and process research, test facility operation, and general computational use.

**PACIFIC SEMICONDUCTORS, INC.:** Germanium and silicon diodes and transistors, high voltage rectifiers, subminiature rectifiers, voltage variable capacitors.

Number of employees: 22,000  
Estimated 1958 Sales: \$335,000,000  
Plants in Los Angeles, Bell, Culver City and Long Beach, California. Denver, Colorado. Michigan City, Indiana. Cambridge, Massachusetts. Warren and Portland, Michigan. St. Louis, Manchester and Sullivan, Missouri. Cleveland, Euclid, Willoughby, Minerva, and Columbus, Ohio. Danville and Harrisburg, Pennsylvania. Roanoke, Virginia. St. Catharines, Ontario.



# If the job calls for **TEFLON\*** use R/M and be sure!



Minimize the risk of failure of a "Teflon" part or component at a critical point by getting it from Raybestos-Manhattan.

R/M has been in the forefront of "Teflon" development from the beginning. Our engineers know "Teflon" . . . its unique characteristics, its vast potentialities, how it can best serve the needs of a particular industry. Our production men have the know-how and complete plant facilities to follow through. You specify it; they fabricate it.

We understand the complexities of your problems—friction, extremes of temperature, the corrosive action of exotic fuels, etc.—and will give you all possible aid in designing, molding or machining the R/M parts or components you need. Make R/M your headquarters for all the "Teflon" products you need. Call upon your nearest R/M district office for the cooperation you require—or contact us direct.



R/M "Teflon" products for aircraft, missiles and space vehicles include thin-wall tubing (with or without identifying stripe); flexible wire braid covered "Teflon" hose; sheets, tape, rods and tubes; rods, sheets and tubes in certified and stress-relieved grades (X-ray films for sheets and rods are available); centerless ground rods held to very close tolerances.

\*A Du Pont trademark



## RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1  
LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3  
PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

Circle No. 275 on Reader Service Card in Product Review Section

## Aircraft•Missile Engineering

### Materials



ANODIZED strip or wire can be made by this pilot machine at Permaluster. In continuous process, material is anodized in  $\frac{1}{4}$  minute, depending on thickness.

## Aluminum oxide insulation looks good for high temperature wire

Multi-layer coatings with an aluminum oxide base may lead to strip and wire that can take as much as 1900 deg F, recent experimental developments indicate.

THERE is a prime need today for good insulation for wire and strip for solenoids, transformers, etc., that will take temperatures as high as 1000-2000 deg F. One possible answer to this requirement is the use of aluminum oxide coating, which has a melting point of 3660 deg F.

A recent advance in this area was the development of flexible anodic coatings by such firms as Permaluster, Inc., 2012 W. Burbank Blvd., Burbank, Calif. (see *AvAge*, "Anodized Aluminum Wire Takes 1000 Deg F," Sept. '57,

p. 64). Wire with such an anodized coating—of 0.00015-in thickness—could be bent around a radius three times that of the wire without crazing or fracturing the film.

The same firm has since extended its process to provide flexible aluminum oxide coatings for aluminum strip. Work on using such insulation for other metals, such as silver, promises to provide wire and strip that will take temperatures as high as 1900 deg F.

Company officials told SPACE/AERONAUTICS that a pilot line is in operation to produce anodized aluminum strip in widths up to 24 in. Coating thickness on wire or strip can be controlled from as low as 0.00008 up to 0.001 in., they report. A number of transformer manufacturers are testing units using this material, since weight reductions of up to 50 per cent plus space



ings can reportedly be  
ed over conventional ma-  
als.

A. H. Hadley, general man-  
r of Robert M. Hadley Co.,  
Los Angeles, told SPACE/A-  
RONAUTICS his firm is work-  
on a three-phase, 400-cycle  
ver transformer to supply  
tifiers for operation up to  
deg C. So far, he reports,  
anodized aluminum strip  
ks good. The unit has a  
od space factor, he reports,  
has stood up under humid-  
and vibration tests (Mil-E-  
72). The prototype has been  
cessfully tested in ambients  
-55 to +125 deg C. It  
stood a temperature rise  
100 deg C with little or no  
ect on properties.

Pilot runs are also being  
de on copper wire and strip  
in aluminum oxide insula-  
n. The copper must first be  
ted to eliminate galvanic ac-  
n and diffusion in high tem-  
ature operation. Permalus-  
is making material with  
er silver or nickel plate.  
rious research studies spon-  
ed by the services are also  
king into other platings,  
ch as gold.

Work on actual uses of  
minum - oxide - insulated,  
kel-plated copper is still in  
early stages and little data  
presently available. In one  
e, however, Cannon Elec-  
reports successful continu-  
s operation for several days  
temperatures of 1200 deg F  
a prototype dc solenoid  
ide of this wire.

One of the major problem  
as is that aluminum oxide  
ulation tends to be hygro-  
pic in the presence of mois-  
re, which can adversely af-  
ct the dielectric strength.  
is is particularly true at  
gher voltages. One solution  
ggested by Permaluster is to  
pregnate the oxide with such  
aterials as silicone, zirco-  
um, or magnesium oxide.

A major competitor of an-  
odized insulation is ceramic-or-  
nic insulation. WADC is

more on next page

**RADAN**<sup>®</sup>  
SYSTEMS



**ground speed & drift angle  
any time, anywhere, any weather**

One look and the pilot KNOWS. In a glance  
he reads actual ground speed and drift angle,  
displayed on his flight panel — automatically  
and continuously.

The system operates entirely without  
ground aid or celestial fix.

RADAN is the result of GPL's harnessing  
of Doppler for air navigation—an achievement  
comparable in magnitude to the breaking of  
the sound barrier.



**...and now for everyone**

The wraps are off RADAN! The civilian coun-  
terpart of GPL's famous military Doppler auto-navi-  
gators, is ready and available *now* — for anyone and  
everyone!

RADAN Systems have behind them millions of  
miles of experience in transcontinental, oceanic and  
polar flights . . . save precious time and fuel . . . pro-  
vide a priceless margin of safety.

- **RADAN** — accurate: within 1% for ground speed,  
within ½° for drift angle
- **RADAN** — small: 4.4 cu. ft.—light: 89 lbs.
- **RADAN** — operates without ground or celestial aids
- **RADAN** — virtually maintenance-free

Now in quantity production, RADAN Systems  
are manufactured by GPL, who developed and is the  
nation's leading producer of Doppler air navigation  
systems. Address inquiries to: General Precision  
Laboratory Incorporated, Pleasantville, New York.

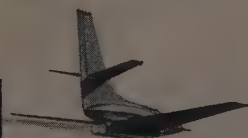


ENGINEERS — GPL achievements have opened up some unusual research and development opportunities. Send resumé to Personnel Manager.  
Circle No. 187 on Reader Service Card in Product Review Section





when  
precision  
"rides herd"



When the finished product comes off the board and takes to the air, the individual skills of all who contribute are tested to the fullest.

Even the prosaic fastener is under stress scrutiny . . . and the men at Chandler are aware of the responsibility placed upon them.

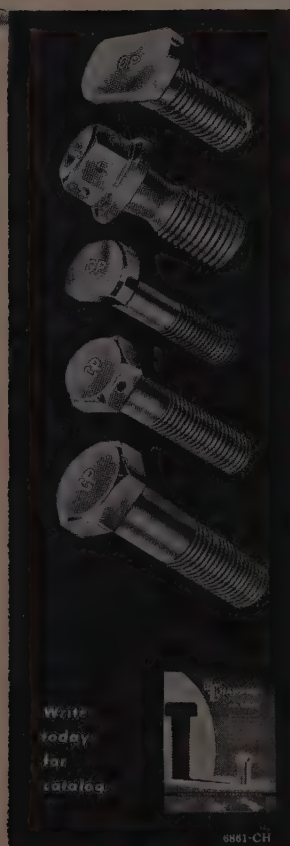
Chandler cold forged fasteners are airborne all over the world in aircraft of all types. They are serving well because they have been produced from the finest steel stock available. They have been inspected and rechecked by skilled technicians.

Chandler rides herd on precision . . . to produce a fastener of the highest standards of precision, uniformity and economy . . . so that precision can ride herd with America's pilots everywhere.

*Specialists in Thread-Rolling  
After Heat-Treating*



1493 Chardon Road • Cleveland 17, Ohio



## WIRE INSULATION . . .

### High Temperature Test Results of Anodized Aluminum Wire\*

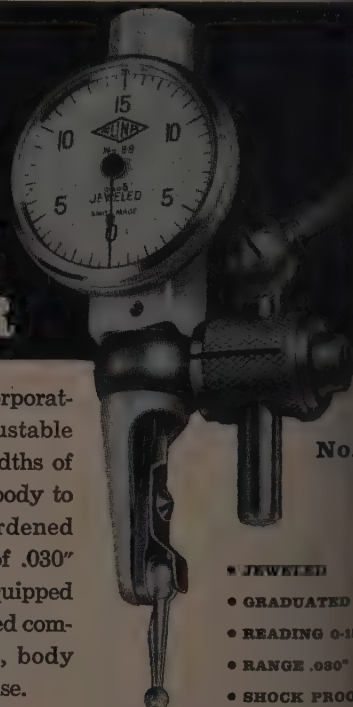
10 Mil Wire	Maximum	Minimum	Average
<b>Mercury Dielectric Test</b>			
1-In. loop	130 V	90 V	104 V
<b>Twisted Pairs Dielectric Test</b>			
1.5-lb tension	560 V	460 V	510 V
After 24 hr @ 90° & 90% RH	430 V	410 V	420 V
After thermal shock	510 V	430 V	470 V
<b>Mandrel Dielectric Test</b>			
0.5-lb. tension			
1/2 In.	300 V	260 V	284 V
1/4 In.	340 V	300 V	324 V
1/16 In.	320 V	290 V	306 V
<b>Insulation Resistance</b>			
Room temperature	300x10 <sup>8</sup> meg-ohms	141x10 <sup>8</sup> meg-ohms	
After 40 hr @ 600° C	87 meg-ohms	58.6 meg-ohms	
<b>Dielectric Breakdown</b>			
After 40 hr @ 600° C	325 V.	300 V.	308 V

### 12.6 Mil Wire

<b>Dielectric Breakdown</b>			
On light coating at:			
23 Deg C	258 V	212 V	226 V
200 Deg C	255 V	220 V	241 V
350 Deg C	238 V	188 V	221 V
600 Deg C	244 V	225 V	237 V
<b>Insulation Resistance</b>			
200 Deg C	9.5x10 <sup>8</sup> ohms	3x10 <sup>8</sup> ohms	4.6x10 <sup>8</sup> ohms
350 Deg C	7.6x10 <sup>8</sup> ohms	1.6x10 <sup>8</sup> ohms	4.0x10 <sup>8</sup> ohms
600 Deg C	11x10 <sup>7</sup> ohms	2.3x10 <sup>7</sup> ohms	7x10 <sup>7</sup> ohms

\*Data from General Electric test program.

## ALINA DIAL TEST INDICATOR



A fully reversible indicator incorporating a clear easy-to-read, adjustable dial, graduated in half thousandths of an inch, a switch lever on the body to reverse action and TWO hardened chrome plated contact points of .030" and .100" diameter that are equipped with a non-slip ratchet. Furnished complete with a universal shank, body clamp, and plush lined steel case.



WRITE FOR LITERATURE AND COMPLETE CATALOG

## ALINA CORPORATION

122 East Second St., Mineola, L.I., N.Y.

Circle No. 3 on Reader Service Card in Product Review Section

Circle No. 163 on Reader Service Card in Product Review Section

SPACE/AERONAUTIC





**SUN ELECTRIC** dc solenoid using aluminum-oxide-insulated, nickel-plated copper wire was operated for several days in a furnace at 1200 deg F. Sun engineers emphasize, however, the new insulation must undergo rigorous test program.



**TRANSFORMERS** using aluminum-oxide-insulated aluminum are being studied by Robert Hadley Co. Test units shown are reportedly have space factor close to unity, are 50 per cent lighter than units using copper foil.

Sponsoring two major development programs in high temperature wire insulation. In the, researchers at Georgia Institute of Technology are studying the use of frits for protecting copper wire. At high temperatures (1300-1500 deg F), researchers report, the ceramic-organic materials they studied presented problems of setting the base metal and adversely affected electric properties.\*

This indicated need for a

D. Walton & J. N. Harris, "High-temperature Insulation for Wire," ADC Technical Report 58-13 (Part I)

more on next page

## THE REQUIREMENT:

To design and build a quick-check, highly accurate, dual system, portable pneumatic test bench for sensing and locating air leakage in the canopy seal and cabin/cockpit of pressurized aircraft.

## THE EQUIPMENT:

The **SUN Model SX-106, Air Leakage Cabin/Cockpit Pressure Tester**. Comprising two separately controlled pneumatic systems, operating from a common 100 psig shop air source, this unit provides a dynamic air flow of 200 SCFM with a pressure load up to 15 psig. Static pressure may be regulated up to 30 psig. Simple controls and instrumentation relate air temperature, pressure and true flow reading to pounds per minute air loss.

## THE BUILDER:

The Aeronautical Division of Sun Electric Corporation — one of the foremost experienced designers and producers of aeronautical and missile testing and support equipment. For any problem involving electrical, electronic, hydraulic, pneumatic, or related equipment, you'll save time AND money by consulting Sun's Engineers **FIRST!**

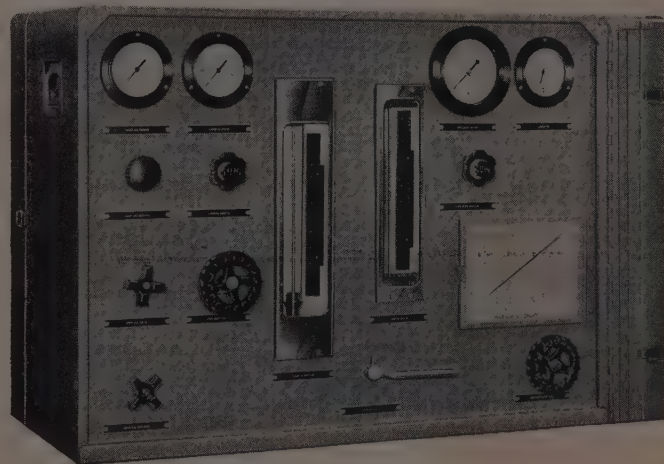
### GENERAL SPECIFICATIONS

Length 38½ inches  
Height 28½ inches  
Depth 22½ inches  
Weight 290 pounds

Operating Range:  
40° F to 120° F at 80 psig

High and Low Range  
Flowmeters — 20 to 200 SCFM  
and 2.9 to 29 SCFM  
±2% full scale

Internal pressure relieving  
components protects aircraft  
against over-pressurization.



Model SX-106 Aircraft Cabin/Cockpit Air Leakage Tester. All connections between tester and aircraft made at rear of unit.

# Sun ELECTRIC CORPORATION

AERONAUTICAL DIVISION • HARLEM AND AVONDALE • CHICAGO 31, ILLINOIS  
Circle No. 12 on Reader Service Card in Product Review Section



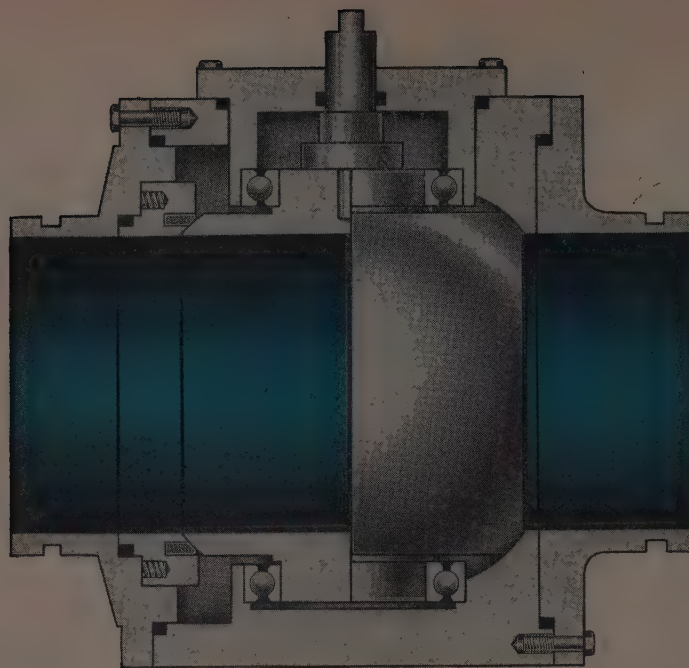


**ALUMINUM OXIDE** insulation for aluminum wire looked promising at temperatures approaching 1200 deg F in General Electric tests. Test coil is shown here after soak at 1200 deg F for 384 hours.

base coating of the wire. So far, indications are that aluminum oxide is best for this coating. The ceramic-organic layer applied to the anodized coating would then solve the hygroscopic problem.

Current programs indicate anodized aluminum wire is good at temperatures as high as 1200 deg F, Permaluster reports. General Electric tests of heavily anodized 10 mil wire showed an insulation resistance of  $300 \times 10^3$  megohms maximum and  $141 \times 10^3$  megohms average for samples of Permaluster wire at room temperature. After 40 hours at 600 deg C, the respective values were 87 and 58.6 megohms. Dielectric breakdown after 40 hours at 600 deg C was 325 V maximum, 300 V minimum, and 308 V average.

Dielectric breakdown for lightly anodized 12.6 mil aluminum wire at 23 deg C was 258 V maximum, 212 V minimum, and 226 V average. At 600 deg C, the respective values were 244, 225, and 237 V. Insulation resistance at 200 deg C was  $9.5 \times 10^9$  ohms maximum,  $3 \times 10^9$  ohms minimum, and  $4.6 \times 10^9$  ohms average. At 600 deg, the values were  $11 \times 10^7$ ,  $2.2 \times 10^7$ , and  $7 \times 10^7$  ohms (see Table). Circle No. 60 on Reader-Service Card for more information.—IS



## HYDROMATICS *FLO-BALL* VALVES

The accepted standard of maximum performance and reliability

### 100% FLOW EFFICIENCY

Hydromatics' exclusive FLO-BALL design provides a straight-thru unrestricted fluid path, exactly equal to the pipe line diameter.

### PERFECT SEALING

Zero leakage is assured through the use of a precision ball—the ideal geometric form for perfect sealing contact.

### LOW OPERATING TORQUE

Ball rotates in precision bearings which absorb all pressure loads. Pressure balanced valve seat further minimizes forces on ball, reducing frictional drag.

### LONG LIFE

Seat is always in sealing contact with the ball surface, resulting in a self-wiping, self-lapping action that insures long, trouble-free life.

### HIGH SPEED ACTION

Only 90-degree rotation is required to fully open or close valve. Full travel as fast as 5 milliseconds.

### RELIABILITY

Simple construction, with only one rotating part, provides built-in reliability and rugged, dependable operation.

### CRYOGENIC AND CORROSIVE APPLICATIONS

Hydromatics' FLO-BALL valves, with new diaphragm sealing and unrestricted fluid path, have been proved the best valves for operation with LOX, Liquid Nitrogen, Helium, Hydrogen Peroxide, Red Fuming Nitric Acid and Hydrazine.

### MODULAR ARRANGEMENT

Only FLO-BALL design, with its rotating valve action, permits side-by-side grouping of several valves, all driven simultaneously by a single actuator.

### VERSATILITY

Only FLO-BALL design makes possible the interchanging of manual, motor or pressure actuators without changing the valve body.

**HYDROMATICS**, the world's leading designer and manufacturer of high performance ball valves for military and industrial applications, offers the most extensive selection of designs to meet all your requirements; Manual, motor or pressure operated. For cryogenic, corrosive or general service media. Pressures from vacuum to 10,000 psi. Sizes from 1/4 inch to 12 inches.

**Hydromatics, Inc.**

70 Okner Parkway, Livingston, New Jersey

## Hydromatics, Inc.

HYDROMATICS FIELD ENGINEERING OFFICES:

Pasadena, 35 N. Arroyo Pkwy., RYan 1-7448 / Denver, 829 15th St., AMherst 6-2714 / Washington, 1413 K St. N. W., STerling 3-3612

Circle No. 188 on Reader Service Card in Product Review Section

SPACE/AERONAUTICS

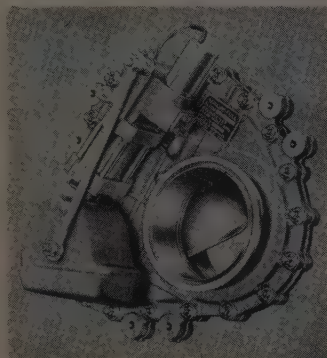


## CABLE JACKET withstands extreme heat

Thermazip is a cable jacket that protects components and cables from high temperature exposure from missile blasts, and engine or jet heat. The aluminized, reflective, asbestos fiber jacket withstands 2000 deg F of continuous operating temperature and 3000 F for brief periods, says The Pertubing Co., Dept. S/A, 752 San Pedro St., Los Angeles 14, Calif. Thermazip, which is closed by plastic or metal zipper track, can be applied very rapidly. It is available in id's from 3/8 in. up, in increments of 1/8 in.

Circle No. 204 on Reader-Service Card

## GATE VALVES for cryogenic use



Gate valves that can be used as pre-valves or fill valves under line pressures up to 60 psi and over a -320 to +250 deg F temperature range are available from Koehler Aircraft Products Co., Dept. S/A, 409 Leo St., Dayton, O. The valves are suitable for systems involving LOX, other cryogenic liquids, and standard aircraft and missile fuels and oxidizers.

Valve actuation can be accomplished manually, electrically, hydraulically, or by pneumatic pressure.

Circle No. 206 on Reader-Service Card

## SERVO SYSTEM has feedback network



This completely-integrated, electro-hydraulic servo system is being used for control of hot gas turbine auxiliary power supply, according to Hydraulic Research and Mfg. Co., Dept. S/A, 2835 N. Naomi St., Burbank, Calif. The device has an output velocity proportional to the input and time derivative of the input electrical command.

A hydro-mechanical rate feedback network is used to generate the derivative computation. The network measures and feeds actuator velocity back to the servo valve flapper to achieve velocity anticipation.

Circle No. 207 on Reader-Service Card

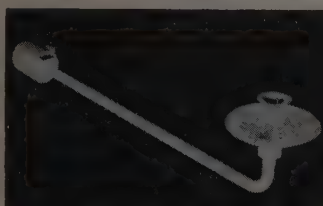
## VOLTMETER aligns missile controls

This phase angle voltmeter is being used for control equipment alignment in the Atlas Missile, says North Atlantic Industries, Inc., Dept. S/A, 603 Main St., Westbury, L.I., N.Y. The device may also be used for phase-sensitive null indication.

Another function includes use as a ratiometer for zeroing and testing precision synchros, servomechanisms, and transducers.

Circle No. 208 on Reader-Service Card

## SENSOR is triple-shielded



Air temperature measurements substantially independent of solar and other radiation are possible with a temperature sensor housed in a triple-shielded enclosure, says Beckman & Whitley, Inc., Dept. S/A, San Carlos, Calif. The device is equipped with an aspirating blower and a support arm.

The thermal-sensitive element is surrounded by a stainless steel inner shield which, in turn, is housed in a cylinder of aluminum. The outermost shielding element is hat-shaped, and it reduces further the maximum solar radiation error. The shields provide radiation shielding effective to a maximum temperature deviation of 0.2 deg F.

Circle No. 209 on Reader-Service Card

## TRANSFORMER has doubled range

The null position of the Series ES-L has been placed at the end of core travel for increased range, says Schaevitz Engineering Dept. S/A, Route 130 & Schaevitz Blvd., Pennsauken, N.J. The single-ended linear variable differential transformer has a range about twice that of a conventional transformer of similar size.

It has a nominal frequency range of 60 to 10,000 cps. Ambient temperature range is -65 to +200 deg F.

Circle No. 210 on Reader-Service Card

more on next page



## 1/2" MOTORIZED FLO-BALL VALVE 100% flow efficiency — for general service media up to 3000 psi

Extremely light weight and compact, suitable for a wide range of aircraft and missile applications, both airborne and ground support. Provides perfect sealing and 100% flow efficiency for general service media (jet fuels, hydraulic fluids, water, alcohol, helium, hydrogen, oxygen, etc.) at pressures up to 3000 psi and temperatures from -65° to 200°F. The DC motor actuator includes automatic current shut-off and a positive Geneva-Lock mechanism. Valve is of bi-stable design — in the event of electrical power failure, the valve will remain in its last position, either open or closed. Included is a built-in microswitch for remote observation of valve position. Flanges, which are removable and interchangeable, may be specified per AND-10050, AND10056, NPT or ASA.



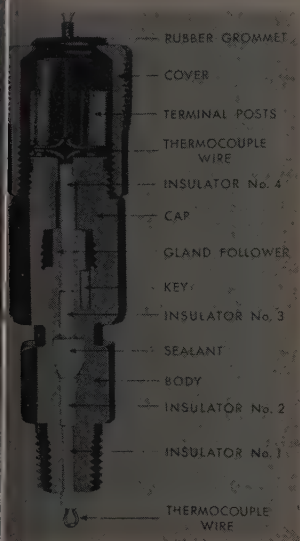
## FLO-BALL PROPELLANT VALVE Dual line flow control of cryogenic media at 1000 psi

For simultaneous flow control of Liquid Oxygen and Fuel, this prop valve provides zero leakage control of a 3/8" LOX line and 1/2" Fuel line at pressures up to 1000 psi and temperatures as low as -350°F. A single-acting, spring-return pressure actuator drives a precision mechanical linkage which controls both valves, thus insuring constant timing. The valves are extremely fast acting, with response times as short as 10 milliseconds. All dynamic sealing is double with a vent between seals for maximum safety. A sealed, rotary action snap switch permits remote observation of valve position. Valve flanges, available in standard or special styles, are removable and interchangeable.

**Hydromatics, Inc.**

70 Okner Parkway, Livingston, New Jersey  
Circle No. 189 on Reader-Service Card

## THERMOCOUPLE GLAND seals eight wires

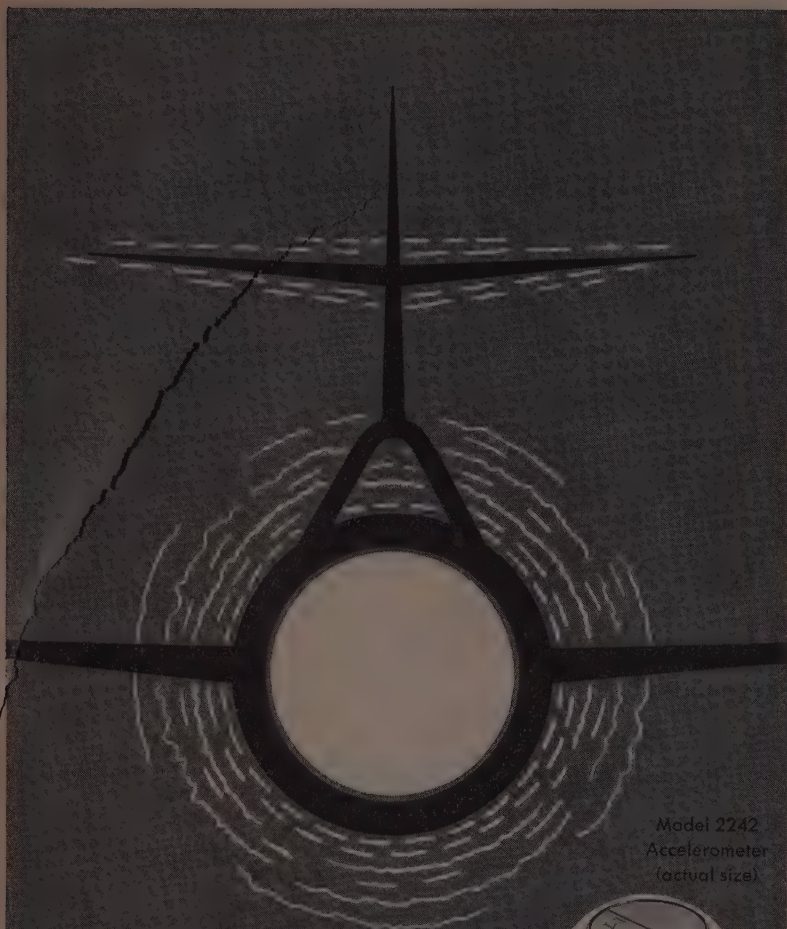


Up to eight bare wires can be terminated and sealed at pressures to .005 mu to 20,000 psi by Type C bare wire thermocouple gland, says Conax Corp., Dept. S/A, 2300 Walden Ave., Buffalo 25, N.Y. An open-end tube available for mechanical protection of the wires in high velocity or viscous fluids.

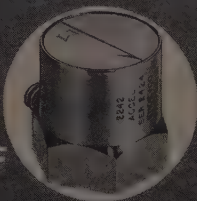
The gland is furnished for assembly or completely assembled. It is suitable for 14, 20 or 24-gauge wire. Immersion depth of the junction is adjustable to any length. The glands are made of 304 stainless steel and are equipped with neoprene, Teflon or lava flanges, and ceramic insulators.

Circle No. 205 on Reader-Service Card





Model 2242  
Accelerometer  
(actual size)



## MEASURE VIBRATION AT 500° F

Endevco Accelerometers employing Piezite Element Type II, measure vibrations and shock from -100° F to +500° F without correction. Complete cable and cathode follower systems to withstand 500° F are part of the many accessories for making up Endevco systems for flight and laboratory use. Endevco isolated compression accelerometer systems effectively measure 10 g of vibration in a 160 db noise field with signal/noise ratio of 20 to 1.

Calibration techniques and methods of best using accelerometers are discussed in a new Endevco Engineering Manual. Write for a copy. It will be helpful in solving your accelerometer requirements.

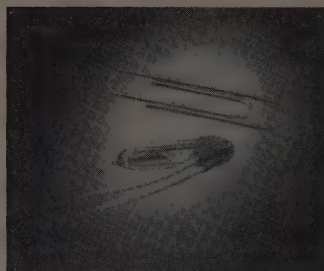
Dynamic Instrumentation  $\Sigma$

**ENDEVCO CORPORATION**  
Department B, 161 East California Street, Pasadena, California

Circle No. 190 on Reader Service Card in Product Review Section

## PRODUCT REVIEW

### SWITCH is very light



A tiny mercury switch that weighs 1.8 gm, including leads, offers sensitive, trouble-free operation in applications such as computers, scales and other devices, says Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill. The AS419A1 may be mounted in any position through 360 deg around its longitudinal axis, and it may be actuated by slow, snap or fast-tilting action.

The low shift of mass involved in actuation facilitates gang-mounted assemblies. The spdt switch is rated for a resistive load of one amp, 30 V ac or dc, and an inductive load of .75 amps, 30 V ac or dc.

Circle No. 211 on Reader-Service Card

### PRESSURE SWITCH is adjustable



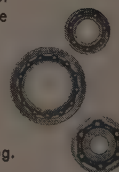
A switch designed for all aircraft hydraulic systems requiring a pressure sensor to actuate the electrical apparatus has been developed by Consolidated Control Corp., Dept. S/A, Bethel, Conn. The unit, Type 6512, features an enclosed snap action and an operating point that is adjustable within the pressure ranges of 500 to 2000 psi and 2000 to 3500 psi.

The switch is made with a lapped piston or an O-ring sealed piston hydraulic actuator. In addition to standard aircraft fluids, the operating media include MIL-0 5606 hydraulic fluid and MIL-1 7808 oil. The spdt unit has a contact rating of five amps resistive or 2.5 amps inductive at 28 V dc.

Circle No. 212 on Reader-Service Card

## Split-Second Starters with Super Finishes

Advanced retainer design and rigid manufacturing control for MPB bearings eliminate torque pulses due to hang-up; micro-finished balls and raceways assure low torque with minimum variations and maximum reliability. Write MPB Inc., 1401 Precision Park, Keene, N. H., for catalog.



MPB helps you perform miracles in miniaturization

# MPB

MINIATURE PRECISION BEARINGS INC.

Circle No. 191 on Reader Service Card in Product Review Section

SPACE/AERONAUTICS



## COUNTER has built-in readout

High-speed electronic counting inline-inplane digital presentations have been combined in a frequency-period counter with a range of zero to 220 kc. The Model B, whose applications include and piston engine test cells, anemometer test stands and miscountdown tests, has a memory unit that holds readings while counter cycles to accumulate data, says Computer Measurements Corp., Dept. S/A, 5528 Highland Ave., North Hollywood, Calif.

The period range is ten usec to 0.000 sec. Numerals are 2 1/4 in. Each digit consists of 40 small incandescent bulbs that make readings visible up to 150 ft. The device is designed with a temperature-compensated, crystal-controlled time base. Six internal or external gate pulses are available for frequency measurements. For period measurement, six internal standard frequencies may be counted for direct readout.

Circle No. 213 on Reader-Service Card

## FOIL in 15 in. width



Ductile Co-Netic magnetic welding foil is now offered in 15 in. width. The new width simplifies the enclosure of a much larger volume by minimizing the number of junctions needed when the foil was available only in 4 in. widths, says Magnetic Field Div., Perfection Mica Co., Dept. S/A, 1322 N. Elston Ave., Chicago, 22, Ill.

The foil can be trimmed to any dimension or outlined with a pair of ordinary scissors and is easily formed by hand. One or more layers can readily be applied and their effects observed. Co-netic foil is non-shock sensitive, non-retentive, does not require periodic annealing and attenuates low level fields.

Circle No. 214 on Reader-Service Card  
more on next page



Shock wave around a simulated missile

## SUPERALLOYS for supersonic performance

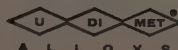
We develop them. And through modern vacuum melting produce them to the closest possible limits of chemical control and uniformity of mechanical properties for use in such critical components as aircraft turbine blades, buckets and skin material for missiles and rockets. UDIMET 500, one of our well established vacuum melted alloys, combines unsurpassed stress-rupture life with excellent ductility and fatigue strength in the 1200°F to 1800°F range. At 1200°F, for example, its tensile strength is 180,000 psi—at 1600°F, 100,000 psi. For further information concerning applications of these superalloys to your products, write to address below.

## VACUUM MELTING provides these properties

- High temperature corrosion resistance
- Increased ductility
- Extreme cleanliness
- Precise chemical control
- Longer stress-rupture life
- Increased tensile strength
- Better fatigue resistance
- Greater yield strength
- Greater impact resistance
- Greater creep properties

# METALS DIVISION OF KELSEY-HAYES

KELSEY-HAYES CO.



NEW HARTFORD, N. Y.

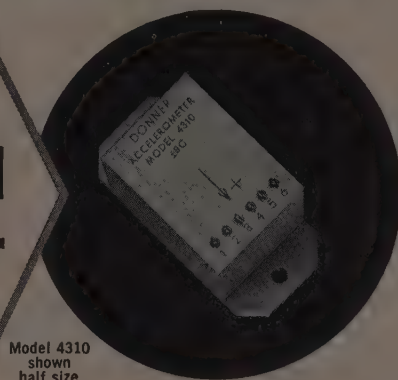
U. S. PAT. NO. 2,411,111

SOME ALLOYS COVERED BY U.S. PATENT #2,411,111



# HIGH OUTPUT -HIGH RESOLUTION

## 0.1% Transistorized Accelerometer



Model 4310  
shown  
half size

Donner's new transistorized Model 4310 accelerometer is designed for demanding measurement and control functions under severe environmental conditions. With applications in telemetering, navigation, control, gyro-erection, and short range inertial guidance, the 4310 is especially appropriate where low weight, small size, and high output are important considerations. When an especially small light weight sensing unit is needed, the acceleration sensing portion of the instrument can be separated from the servo-amplifier. Typical applications in this category include gyro and platform measurements of acceleration, velocity, and displacement.

### OPERATIONAL HOOKUPS OF 4310

A variety of specific output arrangements are possible with the standard Model 4310 Accelerometer. For a full scale voltage output of approximately  $\pm 7\frac{1}{2}$  volts, jumper terminals 1 and 2, read output across 1 and 3. For a full scale current output of approximately  $\pm 1.5$  ma, connect a series load between terminals 1 and 2. For a standardized voltage output, connect a resistive voltage divider network across 1 and 3 with a total resistance of approximately 5000 ohms to yield any prescribed output below  $\pm 7\frac{1}{2}$  volts full scale. Standard modifications of the 4310 include provision for biasing of output; fluid-filling for mechanical rejection of high frequency vibration; and operation from 0-28 volts dc or  $\pm 28$  volts dc with higher output.

### KEY SPECIFICATIONS

NON-LINEARITY PLUS HYSTERESIS	Within 0.05% deviation from best fitted straight line
STANDARD RANGES	Between $\pm 0.1$ g full range and $\pm 30$ g full range. Lower and higher ranges available on special order.
RESOLUTION	Better than 0.0002% full scale
WEIGHT	3.5 ounces net
OUTPUT	$\pm 7\frac{1}{2}$ v dc and/or $\pm 1.5$ ma full scale
EXCITATION	Plus 15 v dc, 5 ma max.; minus 15 v dc, 5 ma max.
DOMESTIC PRICE	Standard instrument \$450.00 F. O. B. Concord, California. Modifications extra.

Donner engineering representatives are located in principal areas. For the name of your nearest representative and complete technical information, please address Dept. 091.

**DONNER SCIENTIFIC  
COMPANY**

CONCORD, CALIFORNIA

Phone MU1berry 2-6161 • Cable "DONNER"

Circle No. 192 on Reader Service Card in Product Review Section

### PRODUCT REVIEW

#### RELAY for dry circuitry

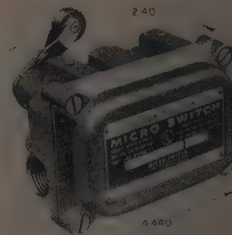


This HG-4SL series relay in size and mounting dimensions, meets proposed MS drawings and MIL-R-25018 relay specifications. Rated for dry circuit operation through ten ampere contacts, it is available in one, two, three, and four pole Form A, B, or C contact arrangements, says HI-G, Inc., Dept. S/A, Bradley Field, Windsor Locks, Conn.

It can be operated from voltage sources from four volts through 250 V. It meets MIL-S-901B shock specifications.

Circle No. 215 on Reader-Service Card

#### SWITCH SERIES is explosion-proof



A new series of explosion-proof switches feature double conductive openings. Designed the EX series, they carry full Underwriter Laboratories listings for hazardous atmospheres of Class I, Group I (ethyl ether vapor) and Group I (gasoline, petroleum naphtha, alcohol, acetone, lacquer solvent vapors, and natural gas); Class I Group E (metal dust), Group (carbon black, coal and coke dust) and Group G (grain dust); switches have adjustable roller-actuator with non-sparking rollers, says Micro Switch, Dept. S/A, Freeport, Ill.

The aluminum alloy housing of the EXL series has ample room for wiring through both conductive openings.

Circle No. 216 on Reader-Service Card  
more on page 16

### First choice of the rocket and missile industry...

Three superlative Marsh products are widely used and approved by the aircraft and missile industry:

#### MARSH Pressure Gauges...

because they combine the most advanced features ever found in pressure, vacuum and compound gauges. There is a Marsh Gauge for every conceivable application.

#### MARSH Needle Throttling Valves...

because they are guaranteed to give micrometer regulation at HIGH pressures—pressure up to 10,000 psi—and any temperature up to 500° F.

#### MARSH Dial Thermometers...

because they offer the precision and accuracy a precision industry demands. Most complete line; wide temperature ranges, dial sizes, patterns, finishes.

All Marsh products available with AND threads

**MARSH**

New catalog  
covers all  
details

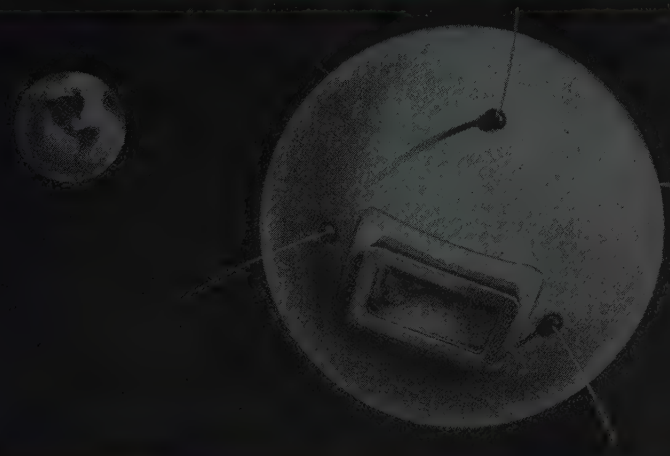
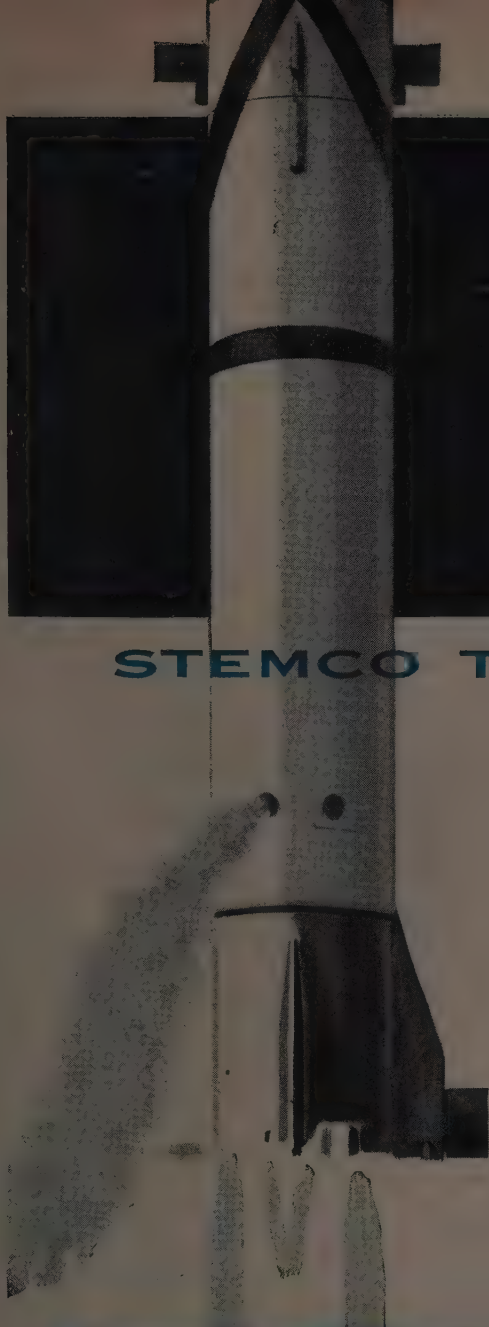
MARSH INSTRUMENT CO., Sales Affiliate of Jas. P. Marsh Corp. Dept. 43, Skokie, Ill.  
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta,  
Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

Circle No. 193 on Reader Service Card in Product Review Section

SPACE/AERONAUTICS



# New Product Announcement



## STEMCO TYPE MX\* THERMOSTATS

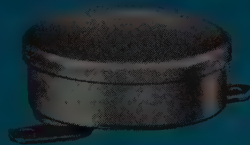
especially designed for missile, avionic  
and electronic applications

New Stemco Type MX Thermostats are miniature snap-acting units designed to *open* on a temperature rise. Being compact, lightweight units able to withstand high G's under wide ambient temperature ranges, Type MX thermostats are ideal for missile, avionic and other electronic applications where close temperature control is mandatory.

Basic design flexibility of the Stemco Type MX Series means the units can be supplied from regular production runs in a wide variety of models, both semi-enclosed or hermetically sealed. Ceramic or metal bases for semi-enclosed units, round enclosures or CR-7 crystal cans for hermetically sealed units. Several types of terminal arrangements, mounting provisions, brackets, etc., are available.

Stemco Type MX thermostats give you performance . . . small cubage . . . rugged reliability . . . *at a production price.*

\* 2° to 6°F differentials available



TYPE MX *Hermetically Sealed* — Electrically independent bimetal disc. Rated at 2 amps at 115 VAC and 28 VDC, based on 250,000 operations.



TYPE MX *Semi-Enclosed* — Metal base shown; also ceramic base types. Bulletin 6100 for data on hermetically sealed and semi-enclosed types.

Circle No. 194 on  
Reader Service Card  
In Product Review  
Section

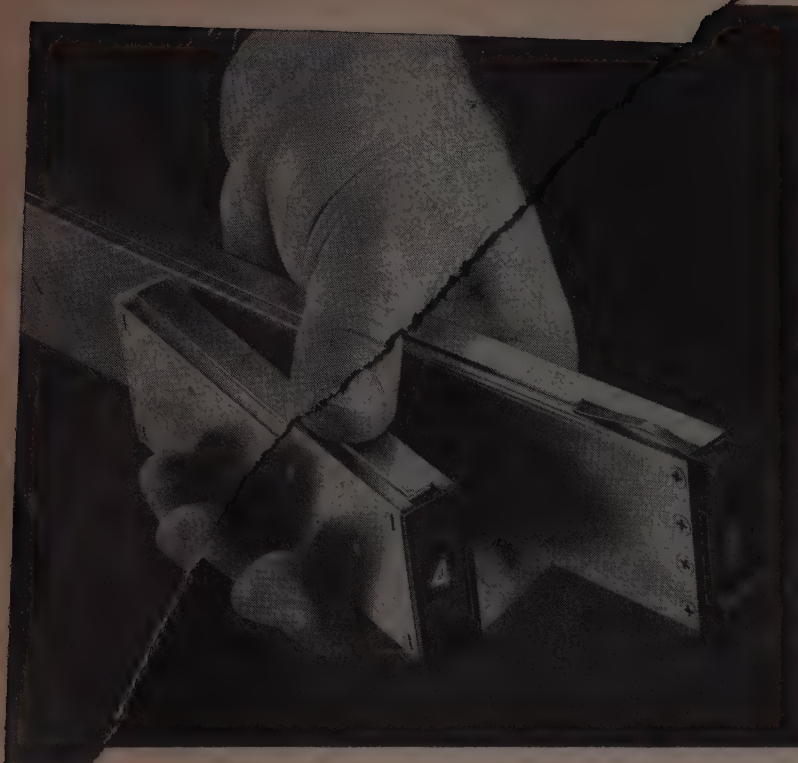
STEVENS manufacturing company, inc.  
Mansfield, Ohio

STEMCO

THERMOSTATS

AA-T285





## Compact! Easy to Read! Union Data Display Indicators

**Union Switch & Signal** makes two types of electro-mechanical, DC-operated data display indicators: digital types, displaying 10, 12, or 16 characters on a wheel; and alpha-numerical types, displaying up to 64 characters on a MYLAR\* belt. Character assignments can be furnished as required.

**TRANSLATION** Both Digital and Alpha-Numerical Indicators operate directly on binary codes on a null-seeking basis. This eliminates the need for external equipment for translation from binary to decimal code, as required with other display devices.

**VISUAL READ-OUT** Indicator packages are designed for quick, easy readability, even when indicators are mounted in rows.

**INFINITE RETENTIVITY** The indicators require power only during the response time, because they are of the null-seeking type. Once positioned, the indicators *retain* the data visually and electrically until a new code is transmitted.

**ELECTRICAL READ-OUT** The design of the decoding and control portions of the indicators provides electrical read-out of data in the same form as the input. The data can be read continuously or periodically without erasing the stored information.

**USES** These indicators can be used in the output of digital computers, in teletype receiving equipment, in telemetering systems, or wherever data needs to be displayed.

\*Dupont's synthetic fiber.

Bulletin No. 1015 gives you complete information.

*"Pioneers in Push-Button Science"*

**UNION SWITCH & SIGNAL**  
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY —  
PITTSBURGH 18, PENNSYLVANIA

Circle No. 195 on Reader Service Card in Product Review Section

### PRODUCT REVIEW

#### TORCH IGNITER for turbo-jets

This torch igniter, designed for high altitude turbojet requirements, features the use of a combination of oxygen and JP-4 fuel to provide a high velocity ignition flame eight to ten inches in length at a calculated temperature of over 3000 deg F. Each igniter unit produces 950 btu/min, or 7500 joules, says Carleton Aviation Co. Inc., Dept. S/A, East Aurora, N. Y.

The igniter nozzle operates over a wide range of external pressure conditions without variation in fuel or oxygen pressures. The igniter is impervious to high or low operating temperatures.

Circle No. 217 on Reader-Service Card

#### COUPLING passes severe burst test

The Type 5-5002-8 quick-disconnect coupling for missile and aircraft hydraulic and fuel lines has withstood 22,000 psi in a burst test, according to On Mark Couplings, Inc., Dept. S/A, 4440 York Blvd., Los Angeles 41, Calif. Be-

cause the device contains neither steel balls or dogs, it can be manually connected or disconnected under high pressure.

The design is also available in remotely actuated couplings. The locking mechanism of the device has a 360-deg gripping action, and it will compensate itself as wear occurs.

Circle No. 219 on Reader-Service Card

#### SHIELDING in large sizes

A neutron shielding material for atomic power plant use is now available commercially in its largest plate and sheet sizes to date, says Aluminum Co. of America, Dept. S/A, 1501 Alcoa Bldg., Pittsburgh 19, Pa. It may be obtained in sizes of 48x120 in., and 36x96 in. thicknesses for both sizes are .250 and .125 in.

Boral plate .250 in. thick is reported to have an effective shielding power equal to that of a 25-in. concrete slab. The material is available in two standard temperaments, annealed and as fabricated.

Circle No. 220 on Reader-Service Card  
more on page 16

#### \$1064 to Overhaul Aircraft Generator at Factory \$60 to Rhodium Plate Commutator and Slip Rings

##### WHICH ONE WOULD YOU PREFER?

Dalic plating makes the difference. Using a specially developed rhodium plating solution and Dalic selective plating equipment, useful operational time of the main generator of a bomber has been increased to some 350 hours. Formerly, time between mandatory overhauls was only about 70 hours.



**SAVINGS:** Two or three overhauls, at \$1,064 each, plus cost of time and labor to remove and reinstall generator.

If you're concerned with military or civil aircraft, missile controls, servos, high-quality electrical equipment, investigate rhodium plating with Dalic equipment. It offers the following advantages:

Longer commutator life • Reduced contact resistance • Higher starting and running torques • Elimination of static and noise in radio and other electronic equipment • Reduces temperature by as much as 80° C • Increased power/current ratio

For further information on Dalic plating, write to:

MARLANE DEVELOPMENT CO.  
153 East 26th Street  
New York 10, N. Y.  
PIDDINGTON & ASSOCIATES LTD.  
3219 East Foothill Blvd.  
Pasadena, Calif.

OHIO METACHEMICAL, INC.  
2742 Second Street  
Cuyahoga Falls, Ohio  
D & S AVIATION CO., LTD.  
671 Lauretides Blvd.  
Pont Vieux, Quebec

**DALIC METACHEMICAL LTD.**  
121 Judge Road, Toronto, Ontario

Circle No. 196 on Reader Service Card in Product Review Section

SPACE/AERONAUTICS



expanding the  
frontiers of  
technology...  
over the full  
spectrum  
of advanced  
electronics



BRUBAKER ELECTRONICS, INC.  
subsidiary of  
TELECOMPUTING CORPORATION

Brubaker scientists and engineers are dynamically attacking and overcoming the highly specialized electronic barriers associated with space-age technology. A skillful blending of technical ability, competitive production capabilities, and extensive testing facilities has established Brubaker Electronics as top-flight experts in the research, design, and development of complex electronic systems and components for both military and industrial applications. Brubaker's experience, personnel, and capabilities, together with a well-integrated research program, are the reasons why Brubaker equipment is operational on so many of the nation's vital weapons systems.

Past achievements show why Brubaker is superior in the area in which it operates: coding and decoding systems, radar, radar beacons, IFF, telemetering, communications and custom test equipment, highly classified military electronic systems - and such components as networks, delay lines, pulse transformers, switches and relays.

*If you have a problem  
in advanced electronics,  
Brubaker engineers have a solution!  
Wire, write or phone:*

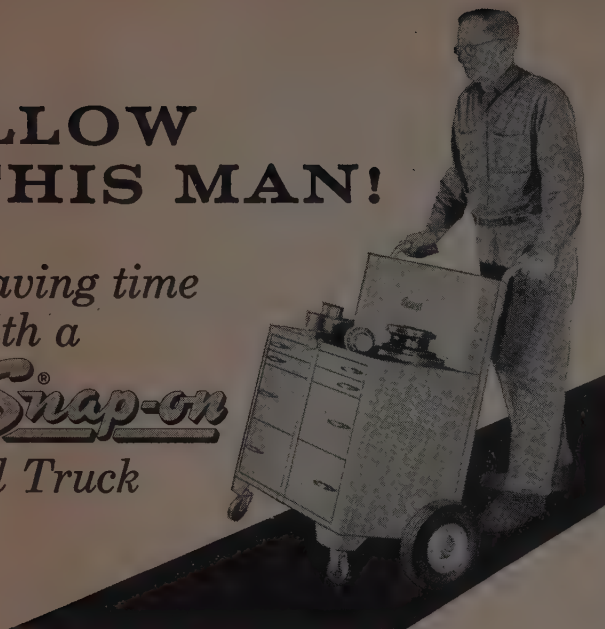
Royal Keeran  
Berne Fisher  
Gene Fredericks  
BRUBAKER ELECTRONICS, INC.  
subsidiary of  
TELECOMPUTING CORPORATION  
3652 Eastham Drive  
Culver City, California  
Telephone: TE 6441  
TWX Culver City, Calif. 7239





# FOLLOW THIS MAN!

He's saving time  
with a  
new **Snap-on**  
Tool Truck



Up a stairway on a hurry-up job, nothing to it  
with the big, 10-inch diameter, semi-pneumatic balloon tires.

Emergency repair work across the plant,



compact Tool Truck carries full tool selection to the job.

Job in another building,



the Tool Truck

eases heavy loads over rough pavements or tracks. Drawers

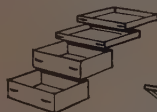
are held shut during travel by a padlocked bar.



The new Snap-on Tool Truck is invaluable wherever tools

or parts transport is needed. Plenty of tool space with four

husky drawers.



Upper panel section is par-

titioned for nuts, bolts, parts.



Ample storage space

throughout.



A demonstration will prove the  
Tool Truck's money-saving ability.  
Call your nearest Snap-on branch or  
write us direct.

## SNAP-ON TOOLS CORPORATION

8080-A 28th Avenue • Kenosha, Wisconsin

Circle No. 198 on Reader Service Card in Product Review Section

## PRODUCT REVIEW

### INERTIA SWITCH actuated by vibration

Once actuated, the ISA1 inertia switch will remain open and cannot be jarred back into an unactuated position. To reset the switch, a manual reset button is provided. Electrical reset may also be provided, says Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill.

The switch operates when subjected to a thrust in any horizontal direction. A vibration of thrust under the minimum duration of 1/30 of a second will not actuate the switch. Force-of-actuation settings are factory adjusted and may be supplied from 1.5 to 10 or more G, depending on requirements.

Circle No. 221 on Reader-Service Card

### CLAD-COPPER WIRE for high temperatures

Oxalloy 28 is a copper wire that has been clad with a chrome-iron alloy to enable it to withstand high temperature (1300 deg F), and corrosive and oxidizing conditions, says Sylvania Electric Products, Inc., Dept. S/A, Warren, Pa. The conductor is said to be ideal

for use as leads to electrical appliances and vacuum tubes, and a hook-up wire.

The wire is available in round wire sizes from 0.005 to 0.250-in. in dia. and in tempers ranging from soft annealed to full hard. Ribbon form comes in widths up to 0.125 in.

Circle No. 222 on Reader-Service Card

### SWIVEL FITTING has low torque rating

Torques as low as one lb-in. under all pressure conditions are featured by the Series 131J10 dual swivel fitting, which provides 360-deg swiveling at each end, says Altair, Inc., Dept. S/A, 50 MacQuisten Parkway, South Mount Vernon, N.Y. Other characteristics include low pressure drop, no leakage, and long life.

The right-angle swivel, which is not adversely affected by impulse conditions, is said to be particularly useful where positioning, excess flexing, vibration, or twisting are problems. It has an operating pressure of 3000 psi and a temperature range of -85 to +300 deg F. It is available in 1/8 to 1/2-in. tube sizes.

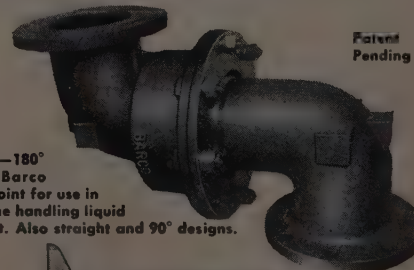
Circle No. 223 on Reader-Service Card

## BARCO

### Flexible Joints for Handling Liquid Oxygen and other missile fuels

BARCO has the specially designed flexible joint which has passed the official "Qualification Test":

- Used in piping on fueling lines handling liquid oxygen, JP4 and JP5 fuel, white and red fuming nitric acid, and other chemicals.
- Provides swivel motion to allow for thermal expansion and contraction.
- High corrosion resistance. Other special designs available. For temperatures from -320°F. to +1,000°F., and higher. Also joints for gas and hydraulic service.



(Right) 6"—180°  
Flanged Barco  
Flexible Joint for use in  
fueling line handling liquid  
propellant. Also straight and 90° designs.

AIRCRAFT DIVISION

**BARCO** Serving Industry Since 1908  
**MANUFACTURING CO.**, 575B Hough St., Barrington, Illinois

Circle No. 199 on Reader Service Card in Product Review Section

SPACE/AERONAUTICS



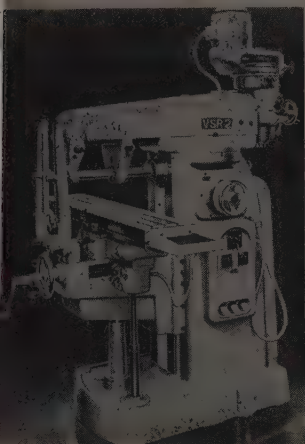
### BATTERY CHARGER has constant current

In this automatic constant current Battery Charger each magnetic amplifier-silicon diode module supplies an adjustable output of one to five amperes  $\pm 1$  per cent dec. The current is constant to a silver cell battery system ranging from one to 50 cells. This permits automatic charging of any types of cell configurations with the same charging unit, says Electric & Mfg. Co., Dept. A, 2806 Clearwater St., Los Angeles 39, Calif.

Automatic shutoff is provided by the four meter relays shown. Other units available.

Circle No. 224 on Reader-Service Card

### MILLER has triple purpose



The Morey-Ram VSR2 is a combination milling machine that effectively includes three different millers in one machine tool, according to Morey Machinery Co., Inc., Dept. S/A, 383 Lafayette St., New York 3, N. Y. The device's vertical and horizontal spindles, powered by a  $3\frac{1}{2}$  and five hp motor, respectively, can be used simultaneously to mill the same part.

The vertical spindle has 16 speeds, from 65 to 4750 rpm, and the horizontal geared head spindle has 12 speeds, from 30 to 1400 rpm. The miller provides up to 8-in automatic longitudinal feed with preselective-type table feeds of  $\frac{1}{2}$  to 22 ipm, or rapid traverse of 100 ipm. Its 48x10-in table will oscillate and can be used in surface grinding when table stops are in place. The lead screw, which runs in oil at all times, is three in. in diameter.

Circle No. 225 on Reader-Service Card  
more on next page

Simmonds engineers are accustomed to seeing their way clearly through challenging problems, because precision and high performance are a must in all our products . . . sensitive electronic fuel management systems, fuel injection systems, electronic instruments and precision mechanical equipment. The size of our organization permits flexibility and speed in the application of new ideas. We are well known also for the exceptional service we render our customers.



*We remove Blueprint Blindfolds...*



**SIMMONDS**  
AEROCESSORIES, INC.

GENERAL OFFICES: TARRYTOWN, NEW YORK • BRANCH OFFICES: GLENDALE, CALIFORNIA • SAN DIEGO, CALIFORNIA • WASHINGTON, D. C. • DAYTON, OHIO  
ST. LOUIS, MISSOURI • DALLAS, TEXAS • DETROIT, MICHIGAN • SOLE CANADIAN LICENSEE: SIMMONDS AEROCESSORIES OF CANADA LIMITED, HAMILTON, ONTARIO



Circle No. 200 on Reader Service Card in Product Review Section

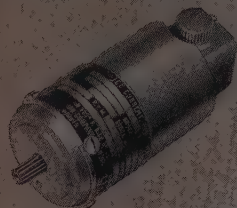


THE MARK OF QUALITY

BARBER  
COLMAN

## d-c small motors

compact, powerful - up to 1/10 hp



### permanent magnet

Only Barber-Colman permanent magnet motors feature the patented symmetrical, progressive lap winding which provides true electrical balance, higher efficiency, superior commutation, and low radio noise output. Motor characteristics range from 6 to 115 volts d-c, 5,000 to 20,000 rpm, outputs up to 1/10 hp. Various mountings and shafts available. Ideal for many aircraft or industrial equipment applications.



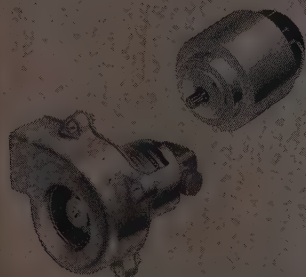
### split-series

Barber-Colman split-series motors are available in two frame sizes with continuous duty outputs up to nine millihorsepower. Outstanding efficiency due to excellent magnetic design and symmetrical lap-type armature winding. Electromechanical brakes can be supplied for these motors.



### gearhead

Barber-Colman gearhead motors can be used as small actuators to drive switches, programming devices, camera mechanisms, autopilots, and for remote positioning in industrial automation. Standard EYLM motor with gearhead, illustrated, provides up to 10 lb-in. torque output. Gear ratios from 9.5 to 55.446:1



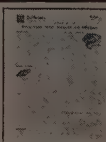
### with blowers, filters

Barber-Colman d-c motor-blower units quickly dissipate heat from hot tubes, circuit components, and other confined equipment. Air volume for a typical 1 1/2-in. centrifugal unit is 20 cfm at 0 static pressure and 70°F. Voltages range from 6 to 115 volts d-c.

Barber-Colman permanent magnet motors also available with lightweight, compact, integrally mounted radio noise filters.

### TECHNICAL BULLETINS ON COMPLETE LINE OF BARBER-COLMAN ELECTRICAL COMPONENTS

Detailed specifications, performance data, product and circuit drawings on polarized relays, resonant relays, d-c motors, tach generators, choppers. Write for your copy on any or all products.



## BARBER-COLMAN COMPANY

Dept. M, 1823 Rock Street, Rockford, Illinois

Small Motors • Automatic Controls • Industrial Instruments • Aircraft Controls  
Electrical Components • Air Distribution Products • Overdoors and Operators  
Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Circle No. 201 on Reader Service Card in Product Review Section

## PRODUCT REVIEW

### MICROSYN is miniature

The T-813 microsyn is a miniature unit useful for position-indicator applications in gyros, process control, and motion and torque amplification, among others, says Sterling Precision Corp., Dept. S/A, 17 Matinecock Ave., Dept. Washington, L. I., N. Y. Size is 7/8 in. od by 1/2 in. overall, and frequency range is 400 to 160 cps.

The T 813 S 1 signal generator has a 0.3 mv/mrad/ma sensitivity at an excitation of 400 cps. The T 813-T 1 torquer has a maximum torque of 3000 dyne-cms and a rated continuous torque of 50 dyne cms.

Circle No. 226 on Reader-Service Card

### SUBMINIATURE SWITCH is explosion-proof

The Type SS subminiature, snap-acting switch is a unit that may be safely used in explosive atmosphere, says Unimax Switch Div., The W. L. Maxson Corp., Dept. S/A, Ives Rd., Wallingford, Conn. It is sealed against moisture, including splashing liquids, and dust.

The switch, which can be supplied with integral and auxiliary type actuators, features a flexible bushing compressed around the actuator inside the phenolic case. Case halves are bonded together. Ratings are: five amps at 125, 250 V ac, or 30 V dc, resistive; and 2 1/2 amps at 30 V dc, inductive.

Circle No. 227 on Reader-Service Card

### TRANSFORMER for transistor use

The units in this line comprise the most complete U.S.-manufactured group of transistor transformers available from stock, according to Crest Transformer Corp., Dept. S/A, 1834 V North Ave., Chicago, Ill. The units are all cored with 48 per cent nickel-silicon steel, are wound on nylon bobbins, and are boxed in translucent plastic housings.

They are made in two core sizes and are available with leads or with T-type straps and stiff, time leads for printed circuits. Dimensions are 3/4x3/4x1 in. and 5/8x5/8x1 in. There are more than 45 transformers in the line.

Circle No. 228 on Reader-Service Card  
more on page 14

# THE TREND IN DRAFTING ROOMS THROUGHOUT THE WORLD IS TOWARD IMPERIAL, THE WORLD'S FINEST TRACING CLOTH

Circle No. 202 on Reader Service Card in Product Review Section

SPACE/AERONAUTICS



**IF ABLATION**

**combined with**

**High Temperature Insulation**

**is your problem...**

**ASTROLITE**

**is your answer!**

The outstanding feature of ASTROLITE is its ability to resist the most severe conditions of high temperature and ablation.

REFRASIL IS IN LARGE SCALE PRODUCTION, IN A VARIETY OF PHYSICAL FORMS, TO MEET THE DEMANDS OF THE MISSILE INDUSTRY.

ASTROLITE WITHSTANDS UP TO 15,000°F for short duration usage.

Write for your copy  
of the new HITCO  
CAPABILITIES Brochure.



**ASTROLITE**

Product Bulletin No.  
PB7-24 describes its  
astonishing resistance  
to ultra-high-temperatures. Write  
for it today.



If you are a Missile or Spacecraft Designer or Manufacturer—with a need for ultra-high-temperature materials, you know the vital importance of low ABLATION rate.

ASTROLITE is a remarkable Refrasil-reinforced plastic with impressive resistance to Ablation and extremely high temperatures—up to 15,000°F. for short-duration applications!

Fabrication techniques for ASTROLITE have been perfected to give optimum fiber orientation to resist Ablation—while retaining maximum insulation properties.

Many major airframe and missile manufacturers are using ASTROLITE today in their Space Technology programs.

Perhaps you can use ASTROLITE for insulation of Rocket Nozzles, Nose Cones, Deflector Vanes, Blast Tubes or Combustion Chamber Liners. Engineering counsel is yours for the asking. Please write to Director of Research.



**H. I. THOMPSON FIBER GLASS CO.**

1733 Cordova Street, Los Angeles 7, Calif. • REpublic 3-9161

WRITE OR CALL YOUR NEAREST HITCO REPRESENTATIVE: EASTERN - Tom Kimberly, 38 Crescent Circle, Cheshire, Connecticut, BRowning 2-6544; Fred W. Muhlenfeld, 6659 Loch Hill Rd., Baltimore 12, Md., VALley 5-3135 • MIDWEST - Gerald L. Weidle, 1347 Pennsylvania St., Indianapolis 3, Ind., ME 5-5607 • SOUTHWEST - Marshall Morris, 20504 W. Berry, Rm. 12, Fort Worth, Texas, WAlnut 4-8678 • NORTHWEST - J. L. Larsen, 5157 Oaklawn Place, Seattle, Wash., PARKway 5-5211 • CANADIAN PLANT: THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston St., Guelph, Ontario, Telephone: TAYlor 2-6530.

Circle No. 231 on  
Reader Service Card  
in Product Review  
Section





## When Airspeed Makes the Weather Horizontal...

When the weather comes in at hundreds of miles per hour, no seal can keep rain out of exposed anti-friction bearings.

For such applications, Torrington Aircraft Needle Bearings and Cam Followers are made available in stainless steel. This material resists corrosion pitting and prevents the formation of areas of increased stress in bearing contact surfaces. Life expectancy is greatly increased for exposed airframe applications.

These advantages of stainless steel, coupled with the high inherent capacity provided by the full complement of rollers, make Torrington Aircraft Type Needle Bearings ideal where space and weight are at a premium. The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.

## TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

TYPE RT—high strength stud with rollers and outer race designed to roll on a hardened steel track.

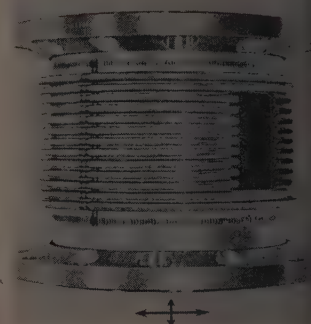
TYPE NBC—inner race, outer race, rollers and washers securely fastened to inner race.

TYPE NBK—inner race, rollers and self-aligning spherical OD outer race mounted in spherical ID ring.

TYPE NBF—extra heavy outer race for heavy rolling loads. Also available in double row NBL series.

## PRODUCT REVIEW

### FLEXIBLE CONNECTOR has smooth-bore lining



Turbulence and pressure drop through the flexible elements of missile and aircraft ducting systems can be greatly reduced through use of a lined flexible connector, according to Flexonics Corp., Dept. S/A, Maywood, Ill. A smooth-bore, stainless steel flexible tube inside the corrugated connector element eliminates turbulence caused by gas or liquid flow across corrugations.

The interlocking convolutions of the liner permit the full offset or axial motion for which the connector is designed, and the liner is relieved so that the corrugated element is the sole pressure carrier. The connector is reported to be especially useful in liquid oxygen systems and pneumatic power piping.

Circle No. 229 on Reader-Service Card

### RELAY uses new principle

This relay, the Mark II, designed on a "revolutionary" new principle, employs a wedge action to achieve a positive contact in both the energized and deenergized conditions. It involves constantly increasing contact pressure during the over-travel period after initial engagement, says Electro Tec, Dept. S/A, South Hackensack, N. J.

The relay is a six-pole, double-throw, miniature, hermetically sealed unit meeting Mil-R-5757C and Mil-R-25018. Important features are its operating ambient temperature range from -65 to +200 deg C, its operating vibration resistance to frequencies from five to 2000 cps at 30 G, its operating shock resistance to 100 G, and its ability to switch currents reliable from dry circuit levels to two amperes.

Circle No. 230 on Reader-Service Card

SPACE/AERONAUTICS

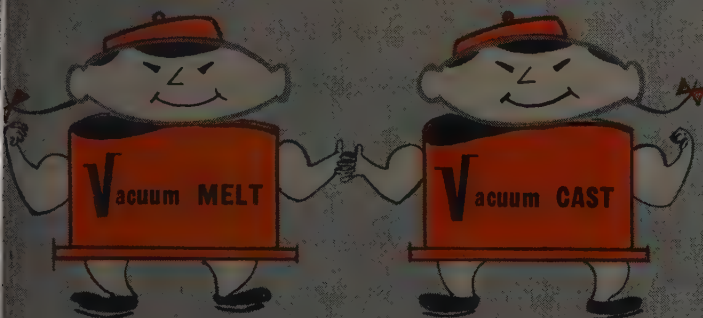


### HYDRAULIC PUMP designed for efficiency

Small, fixed-displacement car-type gear pump for aircraft missile use contains only two moving parts and can reach efficiencies normally restricted to orelex piston types, says Adelson Products, Dept. S/A, Vanowen St., Burbank, Calif. Pump is available for capacities up to 25 gpm, speeds up to 10,000 rpm, and pressures to 4000 psi. Interchangeable pump cartridges

are furnished in four basic sizes. Cartridge construction provides hydraulically and thermally-controlled positive clearances: thus, mechanical drag for all pressures and operating conditions is eliminated. The pump will handle all ordinary oils, fluids and fuels, features low starting torque, and operates over a wide temperature range.

Circle No. 291 on Reader-Service Card  
more on next page



**MISCO**

## INTRODUCES "DOUBLE V"

A technique to enhance the properties of metals demanded by the aircraft, missile and space age vehicles.

"DOUBLE V" signifies the manufacture of cast components using vacuum melted primary ingots subsequently remelted, poured in vacuum, using investment or MONO-SHELL molds. Misco engineers have designed vacuum equipment which permits continuous operation for High Volume Production. Charging of primary ingots, introduction of MONO-SHELL molds, melting and pouring, are carried out in vacuum through the ingenious use of charging locks.

For maximum benefits, melting temperatures are controlled optically and a vacuum pressure of 10 microns or less is maintained on mold and metal during pouring.

ORDER BY  
REQUESTING  
"DOUBLE-V"



Misco now provides a complete range of casting facilities to meet your requirements — AIR — INERT ATMOSPHERE — VACUUM, for your airfoil shapes now and in your future. Send us your inquiries and details of your requirements.

*Misco Precision Casting Company*

Plants in  
BENTON, MICHIGAN  
BENTON, MICHIGAN

**MISCO**

Address inquiries to  
120 Gibbs St.  
WHITEHALL, MICHIGAN  
Whitehall 2-1515

Sales Offices in Principal Cities

PRODUCERS OF AIRCRAFT AND INDUSTRIAL INVESTMENT CASTINGS

Circle No. 232 on Reader Service Card in Product Review Section

MAY 1959

## Torch test of molybdenum at 2600° F.



W-2 CHROMALLIZED specimen, left, completely resists oxidation. At right, volatile oxide vapors are given off by untreated piece as it burns away.

## CHROMALLIZING FOR METAL PROTECTION AT JET-HOT TEMPERATURES

Improve oxidation and thermal shock resistance of metals used in jet engines and similar superheat applications with CHROMALLIZING. This patented method of diffusing chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.



For technical information write to

**Chromalloy Corporation**

450 E. TARRYTOWN ROAD - WHITE PLAINS, NEW YORK  
WHITE PLAINS 6-0020

Chromalloy Corporation Divisions

• PROPELLEX CHEMICAL DIVISION, EDWARDSVILLE, ILLINOIS  
Propellants, cartridge adapted devices, explosives and special chemicals.

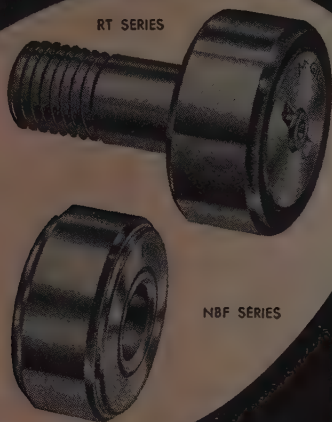
• ELYRIA FOUNDRY DIVISION, ELYRIA, OHIO  
Quality gray iron castings.

Circle No. 233 on Reader Service Card in Product Review Section

167



## McGILL Aircraft needle bearings



...insure performance  
under aircraft  
specifications

Full complement needle bearing capacity, precision accuracy to NAS and AFBMA standards, non-separable construction, lightweight and high material selection standards qualify McGILL RT, NBF, NBL and NBC bearings for aircraft cam, track, and guide roller applications. Surfaces plated as required.

**RT and HRT SERIES**—for use when a cantilever type stud mounting is required. Plating or surface treatment and lubrication holes supplied as application dictates.

**NBF and NBL SERIES**—for use in applications where the bearing O. D. is unsupported and will support rolling loads in cam or track support.

**NBC SERIES**—for applications where bearing O. D. can be supported in a housing. Suitable for slow rotation and oscillation.

Consult our Engineering Department for Special Aircraft bearings built to specification—

Write for free  
Workbook Guide  
to Series and sizes



engineered electrical products



McGILL MFG. CO., INC., Bearing Division  
621 N. Lafayette St., Valparaiso, Indiana

Circle No. 234 on Reader-Service Card

## PRODUCT REVIEW

### CONNECTORS have removable contacts

Removable contacts, silicone inserts, and crimp-type terminations that replace solder pots are featured in these miniature, snap-in connectors, according to The Deutsch Co., Dept. S/A, 7000 Avalon Blvd., Los Angeles 3, Calif. The DS Series of quick-disconnect connectors have precision-machined pins and sockets that are silver and gold plated for maximum corrosion resistance.

The connectors permit no air leakage at 30-psi differential, offer continuous dielectric separation with no voids.

Circle No. 292 on Reader-Service Card

### SWIVEL JOINT is self-lubricating

The design of this cryogenic swivel joint permits liquid oxygen and other liquefied gases in transfer to circulate in the thrust bearing races. The technique takes full advantage of the fluids' lubricity and contributes to improved temperature stabilization and the absence of contaminating lubricants, says Chiksan Co., Dept. S/A, 330 N. Pomona Ave., Brea, Calif.

The joint provides low-torque freedom of movement on a many planes as desired. Joints under two in. in dia handle pressures to 2500 psig over a -320 to +160-deg F range. Units over two in. handle pressures to 150 psig. Available sizes range from 1/2 through 16 in. and feature flanged, threaded, or beveled-for-welding end connections.

Circle No. 293 on Reader-Service Card

### AC GENERATORS for ground power

The ac generators in this line are well suited to the power carts being developed for use with jet airliners, says Jack & Heintz, Inc., Dept. S/A, 17600 Broadway, Cleveland 1, O. The Model G180, one of the units, is rated at 120/160 kva, continuous duty, at 180/240 kva for five min intermittent duty, and at 240 kva for five sec.

The G180 weighs 260 lbs, said to be one-third the weight of comparable commercial generators. It has the same power and electrical design characteristics as generators aboard the new superliners. Other units in the line are rated at 30, 40, 60, 90 and 120 kva.

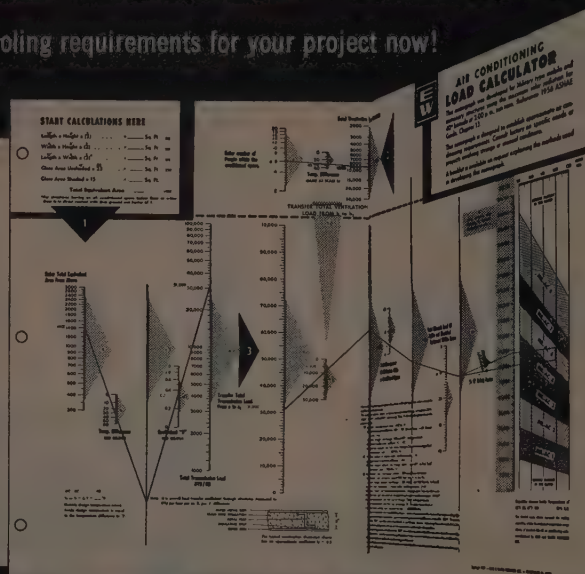
Circle No. 294 on Reader-Service Card

## KW heat problems coming up?

Estimate cooling requirements for your project now!

This helpful, cooling load calculating Nomograph gives you a quick, easy way to analyze potential heat sources, enables you to make your own preliminary estimates of cooling requirements.

Write for your  
copy today!

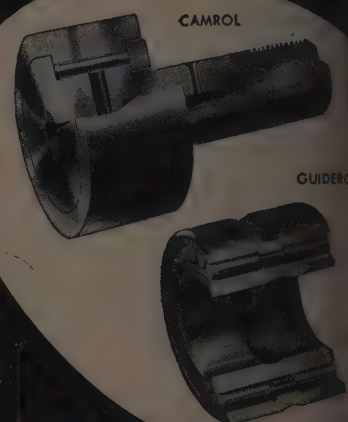


**Ellis and Watts Products, Inc.**  
P. O. Box 33 A, Cincinnati 36, Ohio

Designers and builders of specialized air conditioning equipment: MILL-AC Units, refrigerated liquid coolers, computer cooling equipment, Sawtooth control equipment, Electronic console coolers, air to liquid coolers and large capacity air handlers.

Circle No. 235 on Reader Service Card in Product Review Section

## McGILL CAMROL and GUIDEROL bearings



...add dependability  
to ground  
support equipment

High capacity in limited space plus precision accuracy make these bearings ideal for use as track, guide and support roller in missile and rocket ground support equipment.

**CF SERIES CAMROL bearing** feature an integral stud and heavy duty outer race. They eliminate the cost of building up improvised bolt and roller units and withstand the shock of heavy loading. Also available with seals and pre-lubricated.

**GR SERIES GUIDEROL bearing** provide full complement roller capacity with self-guided rollers for true-running trouble-free performance. SG SERIES sealed GUIDEROL bearings are also available for applications where contamination must be sealed out and lubrication sealed in.

For data on the  
complete line of  
McGill Bearings,  
send for Catalog  
No. 52A



engineered electrical products



McGILL MFG. CO., INC., Bearing Division  
621 N. Lafayette St., Valparaiso, Indiana

Circle No. 236 on Reader-Service Card

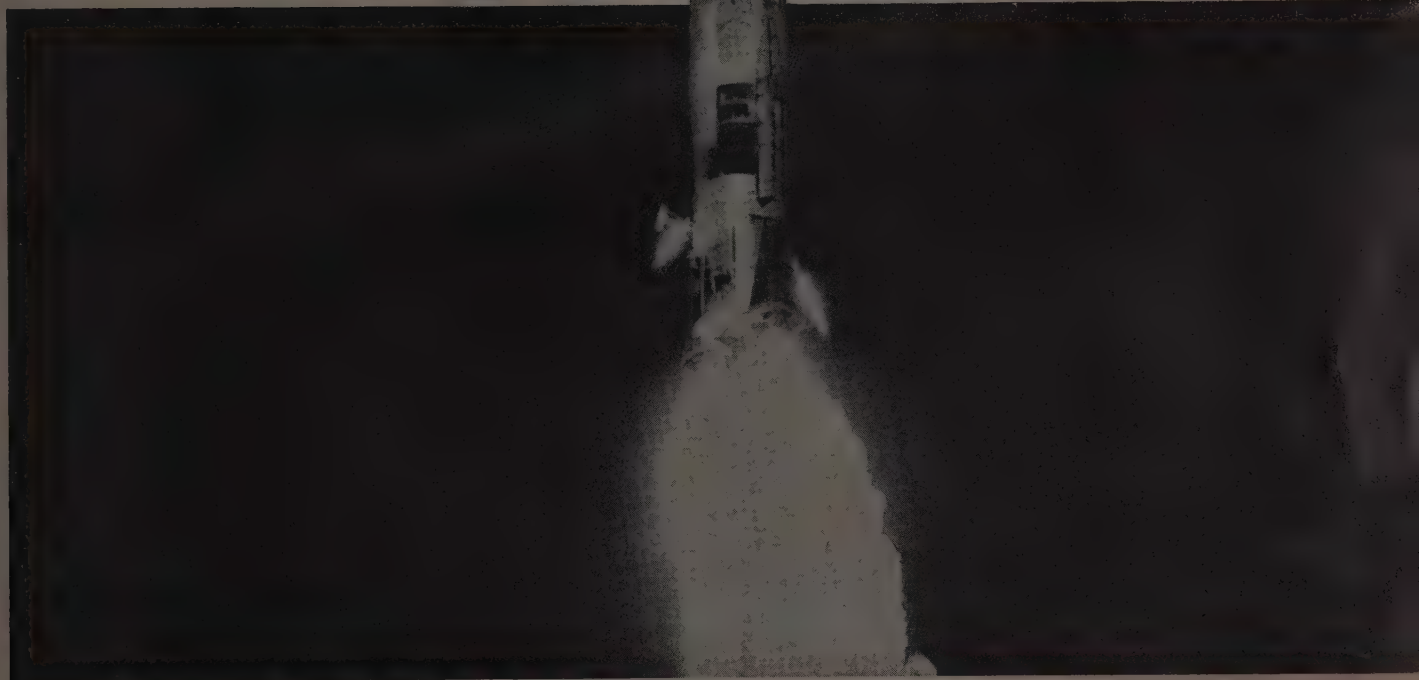
SPACE/AERONAUTICS



Preserver of Peace . . .

**Air Force  
"Sunday  
Punch"**

# ATLAS



Boosted into space by the fiery thrust of three huge rocket engines, the seven-story Atlas intercontinental ballistic missile roars upward from its Cape Canaveral launching pad. Quickly it sheds the frost encrusting the liquid oxygen tank and races to its predetermined destination in the far reaches of the globe. In its size and range and capability, the Air Force Atlas is a

commentary, for all the world to heed, of the necessity to maintain the peace. RCA's Missile and Surface Radar Department has been privileged to design and develop ground check-out, launch control and cabling equipment as a major subcontractor to Convair (Astronautics) Division of General Dynamics Corporation, the Atlas prime weapons systems contractor.



**RADIO CORPORATION of AMERICA.**

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, N. J.



# Bendix-Montrose SYNCHROS



SIZES 11, 15, 18, 23, 31, 37  
ALSO TYPES 1, 3, 5 AND 6 TO MIL-S-2335

ON ALL COUNTS BENDIX IS BEST

- 1. Quality**—MIL-Q-5923C is the only quality standard in the entire plant. There is no lower or commercial quality standard. Constant analysis results in unequalled quality.
- 2. Engineering**—Bendix research and engineering represent the pioneering effort on synchro design and development for the industry. Bendix engineers' extensive training and experience are combined to formulate the most forward thinking in synchro science.
- 3. Production**—Large quantities of precision production tools all operated by skilled workers who are proud of their craftsmanship.
- 4. Inspection**—The most modern gauges, equipment, magnaflux, X-ray, etc., are used throughout the production cycle to assure the precision required to meet the quality demanded by our quality control.
- 5. Environmental**—Continuous type testing of production samples to the various environmental conditions required on all types of units is another Bendix extra to assure quality.
- 6. Service**—Experienced, well trained sales engineers are always on call to help with your synchro application and procurement of standard and special synchro types.
- 7. Delivery**—Production planning and scheduling plus releases of quantities of various synchros in advance of requirements mean delivery on schedule at the lowest cost.

## OTHER BENDIX-MONTROSE COMPONENTS

DYNAMOTORS	AUTOSYN INDICATORS
SMALL DC MOTORS	AUTOSYN PRESSURE TRANSMITTERS
PRESSURE SWITCHES	AUTOSYN POSITION INDICATORS
ORDNANCE SWITCHES	AUTOSYN POSITION TRANSMITTERS

West Coast Sales and Service Office, 117 East Providencia Avenue, Burbank, California  
Canadian Affiliate—Aviation Electric Limited, 200 Laurentien Blvd., Montreal, Quebec  
Export Sales and Service—Bendix International Division, 205 East 42nd Street, New York 17, New York

Montrose Division  
SOUTH MONTROSE, PA.



Circle No. 237 on Reader Service Card in Product Review Section

## data review . . . . .

**ROTARY JOINT**—A waveguide rotary joint, three times larger than the previous largest joint, is described in a 4-page bulletin published by Special Products Div., I.T.E. Circuit Breaker Co., Dept. S/A, 601 East Erie Ave., Phila. 34, Pa.

Circle No. 295 on Reader-Service Card

**DYNAMIC ANALYSIS**—An 18-page booklet entitled "Precision Dynamic Analysis Instrumentation" has been published by The Solartron Electronic Group Ltd., Dept. S/A, Thames Ditton, Surrey, England.

Circle No. 296 on Reader-Service Card

## ELECTROMECHANICAL DEVICES

—Over 120 electric motors, linear actuators, solenoids, power units and other components are covered in the Electro-Mechanical Catalog, prepared by Hoover Electric Co., Dept. S/A, 2100 S. Stoner Ave., Los Angeles 25, Calif. Design data pertinent to the aircraft and missile fields are also included.

Circle No. 297 on Reader-Service Card

**MISSILE DESIGN**—An eight-page brochure outlining its capabilities in the design and manufacture of propulsion systems, rocket engines, missile controls, and propellants, among others, has been prepared by Astrodyne, Inc., Dept. S/A, P.O. Box 548, McGregor, Texas. Research and development and manufacturing facilities are described.

Circle No. 298 on Reader-Service Card

**HEAT TREATING**—An eight-page catalog, "Heat Treatments in Atmosphere Furnaces," which covers protective atmosphere furnace annealing, brazing and hardening of a wide variety of metals, is available from Ferrotherm Co., Dept. S/A, 1861 E. 65th St., Cleveland 3, O. The catalog also deals with protective atmospheres, such as dissociated ammonia, hydrogen, exothermic, argon and helium, in continuous batch or pit-type furnaces.

Circle No. 299 on Reader-Service Card



This unique, flush-mounted oxygen outlet features a retractable, self-purging dust cap that never needs to be removed or pushed aside. It's easy to operate, too — just a soft push to insert and a quick twist to remove. Lightweight — (under 1 oz.) — this outlet is functionally designed — only one moving part. Here is the same principle that has been proved in thousands of hospital pipeline installations — now adapted for aircraft use!

For complete data and free engineering aid from specialists in oxygen piping systems, please write to Aviation Dept.

**Ohio Chemical**  
OHIO CHEMICAL & SURGICAL EQUIPMENT CO.  
Madison 10, Wisconsin  
(A Division of Air Reduction Company, Inc.)

Circle No. 246 on Reader Service Card in Product Review Section

SPACE/AERONAUTICS





# RECTIFIER NEWS

## Highly Specialized Rectifiers for Military and Space-Age Projects Available Through "Prescribed Reliability" Program

### Prescribed Reliability Specification Service

To simplify your procurement, proposed specifications in the latest military style, containing as a part of the requirement the design and life-test pattern found to be correlated with known field failure rates, will be supplied to qualified customers without charge. These specifications will be written to include any degree of reliability in a manner enforceable as a procurement document.

Write on your letterhead for Rectifier News RN458. This 8 page issue describes the steps taken to achieve "prescribed reliability" and the tools provided by International Rectifier to simplify your design and procurement program. There is no obligation, of course.

Prescribed Reliability . . . essential to space-age technology . . . supplies you with enforceable procurement documents that prescribe the reliability needed coupled with the engineering and manufacturing skills required to deliver rectifiers heretofore unavailable . . . designed, manufactured and tested to perform within the prescribed contract specifications!

This concept is the basis for the development of highly reliable, ruggedized rectifiers now available through the Military Products Department of International Rectifier Corporation. Advanced design and manufacturing techniques enable this group to supply you with standard or special units all manufactured to meet the most rigid of existing military requirements *plus* physical and electrical reliability to any degree specified by you or our capable advisory group.

Information on existing military specifications governing rectifiers, as well as forthcoming revisions to specifications and similar data is available from our Military Products Group. If you are engaged in the design or production of military equipment, you are cordially invited to avail yourself of these services, and to learn the great



Typical silicon rectifier of advanced design produced by International Rectifier Corporation for military use. Rating: 12,500 volts PIV at 5 amperes.

extent to which they can prove valuable to you. Address your inquiries to: Military Products Department, International Rectifier Corporation, El Segundo, Calif.

## New Techniques Yield Silicon Solar Cells With Conversion Efficiencies Up to 10%!

From the Astro-Power Division come a new series of rectangular silicon solar cells raising the conversion efficiency to a new high for military and industrial applications. New alloying techniques permanently bond the contact to the silicon wafer making the contact an integral part of the cell itself. This processing improvement results in a substantial gain in operating efficiency . . . minimizes series resistance. Batteries constructed of shingle-type modules will provide an output of approximately 9 watts per square foot of active cell area in bright sunlight. You are invited to investigate these cells for possible application to your industrial control system or remote power source. For engineering specifications, write for Bulletin SR-275, or . . .



CIRCLE READER SERVICE CARD NO. 103

## All International Rectifiers Designed and Manufactured to Meet Rigid Military Specs.

As each new specification governing the design, manufacture or testing of rectifiers for military use was released during the past years, it became standard procedure in the manufacture of *all* rectifier types produced by International Rectifier Corporation for industrial as well as military customers. Those for which rigid military specifications exist and are now available from stock are listed here:

JAN 1N253 per MIL-E-1/1024A

JAN 1N254 per MIL-E-1/989B

JAN 1N255 per MIL-E-1/990B

For high current applications:

JAN 1N412B per MIL-T-12679/26

We would welcome the opportunity to assist you in the application of rectifiers to your military project. Contact our nearest field representative or our factory applications advisory group.

FOR SAME DAY SERVICE ON PRODUCT INFORMATION DESCRIBED ABOVE, SEND REQUEST ON YOUR COMPANY'S LETTERHEAD

EXECUTIVE OFFICES: EL SEGUNDO, CALIFORNIA • PHONE OREGON 9-6281 • CABLE RECTUSA

BRANCH OFFICES: NEW YORK: 132 EAST 70TH ST., TRAFALGAR 9-3330 • CHICAGO: 205 W. WACKER DR., FRANKLIN 2-3888 • NEW ENGLAND: 17 DUNSTER ST., CAMBRIDGE, MASS., UNIVERSITY 4-6520 • PENNSYLVANIA: SUBURBAN SQUARE BUILDING, ARDMORE, PENNA., MIDWAY 9-1428 • MICHIGAN: 199 COOLIDGE HIGHWAY, BERKELEY, MICH., LINCOLN 8-1144

WORLD'S LARGEST SUPPLIER OF INDUSTRIAL METALLIC RECTIFIERS • SELENIUM • GERMANIUM • SILICON

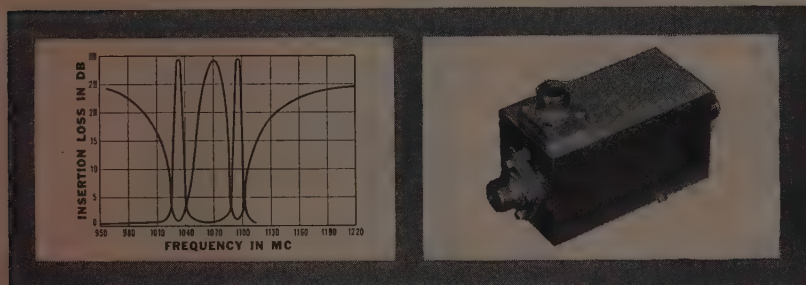


MC RF

# Filters

## Typical of Microphase Techniques:

Bandpass/ Band-Suppression Filter — for simultaneous operation of ATC equipments from a single antenna.  
Notch-valley response adaptable to similar and more complex requirements in other frequencies. Write for literature.



RF COAX and WAVEGUIDE FILTERS,  
standard or to fit your requirements  
LOW-PASS, HIGH-PASS, BAND-PASS, BAND-ELIMINATING,  
DIPLEXERS, MULTIPLEXERS, PRE-SELECTORS

**MICROPHASE  
CORPORATION**

Circle No. 238 on Reader Service Card in Product Review Section

P. O. BOX 1166  
GREENWICH, CONN.  
NORMANDY 1-6200

TWX: GREENWICH, CONN. 759

# ELECTRONIC ENGINEERS!

## SYSTEMS:

Department Managers, Group Leaders, and Senior Electronic Engineers required with minimum five years experience. We need men capable of establishing requirements for, and supervising the development of, major and sub electrical and electronic systems—including check out equipment for missiles and airplanes. Assignments available in:

Flight Control Systems    Navigational Systems    Guidance Systems  
Communications Systems    Infra-red Systems    Radar Systems

## CIRCUIT AND PRODUCT DESIGN:

Group Leaders and Senior Electronic Engineers needed for assignments in the design and development of:

Electronic Packaging    Airborne Digital Computers    Antennas  
Airborne Radar    Controls Instrumentation    Beacons  
Analog Computers    Switching Circuitry    Auto-pilots  
Missile & Airplane Check Out Equipment

**Now...** is the time to join the expanding Electronic Section of either our Airplane or Missile Engineering Divisions. Write today, sending complete resume of education and experience to:

Raymond F. Kaletta  
Engineering Employment Supervisor  
P. O. Box 516  
St. Louis 66, Mo.

**MCDONNELL**

*Aircraft*

(LOCATED IN SUBURBAN ST. LOUIS)

Circle No. 239 on Reader-Service Card opposite last page or send personal resume direct to address mentioned above. GIVE HOME ADDRESS

## DATA REVIEW

**CONTROL DEVICES**—A four-page brochure briefly describing a variety of aircraft and missile hydraulic and pneumatic control devices is available from Hydra-Power Corp., Dept. S/A, Pine Court, New Rochelle, N. Y. Illustrated are powered flight controls, and solenoid and brake valves, among other devices.

Circle No. 300 on Reader-Service Card

**GYROS**—A 64-page, illustrated "Gyro Primer" has been prepared by Ketay Dept., Norden Div., Dept. S/A, United Aircraft Corp., Commack, Long Island, N. Y. It explains how gyros work, gyro terms, and gyro operating principles.

Circle No. 301 on Reader-Service Card

**RESISTANCE TESTER**—an illustrated data sheet describes the Arc Resistance Tester for quality control and material development. Other features and specs are included in this literature by Delsen Corp., Dept. S/A, Glendale, Calif.

Circle No. 302 on Reader-Service Card

**FACILITIES**—An extensive description of its activities in design engineering, environmental testing specifications, flight testing and other technical fields is included in a brochure by Nelson Technical Enterprises, Inc., Dept. S/A, 116 W. Main St., St. Charles, Ill. The publication also covers organization and facilities of the company.

Circle No. 303 on Reader-Service Card

**GEARS**—A profusely illustrated brochure on the techniques and facilities required for the design and fabrication of a large variety of gears has been prepared by Advance Gear & Machine Corp., Dept. S/A, 5851 Holmes Ave., Los Angeles 1, Calif. Typical steps in the creation of a gear are included.

Circle No. 304 on Reader-Service Card

**SWIVEL JOINTS**—Specific details on a variety of swivel joints for aircraft and missile use are contained in Bulletin 5-58, available from Chiksan Co., Dept. S/A, Brea, Calif. The joints, which feature 360-deg rotation in one, two and three planes, have been designed for missile fueling, ground support equipment, and aircraft hydraulic, pneumatic and fuel systems.

Circle No. 305 on Reader-Service Card

**PUMPS**—A four-page, illustrated catalog describing the operation of its variable displacement internal external pump has been issued by Pesco Products Div., Borg-Warner Corp., Dept. S/A, 24700 N. M. Rd., Bedford, O. Schematic drawings for zero and full displacement positions of the VIEP are included along with suggested applications for aircraft.

Circle No. 306 on Reader-Service Card

**PRECISION SYNCHROS**—A new illustrated catalog covering synchro sizes and types for a wide range of applications has been published by Induction Motors of Calif. Div., Induction Motors Corp., Dept. S/A, 6053 Walker Ave., Maywood, Calif. An important feature of the new catalog is a section covering points to consider in synchro selection such as types (control torque), military designations and engineering data. Included are inquiry sheets, and dimensional and electrical data and materials.

Circle No. 307 on Reader-Service Card

more on next page

from  
PLANNING  
to  
PRINTING

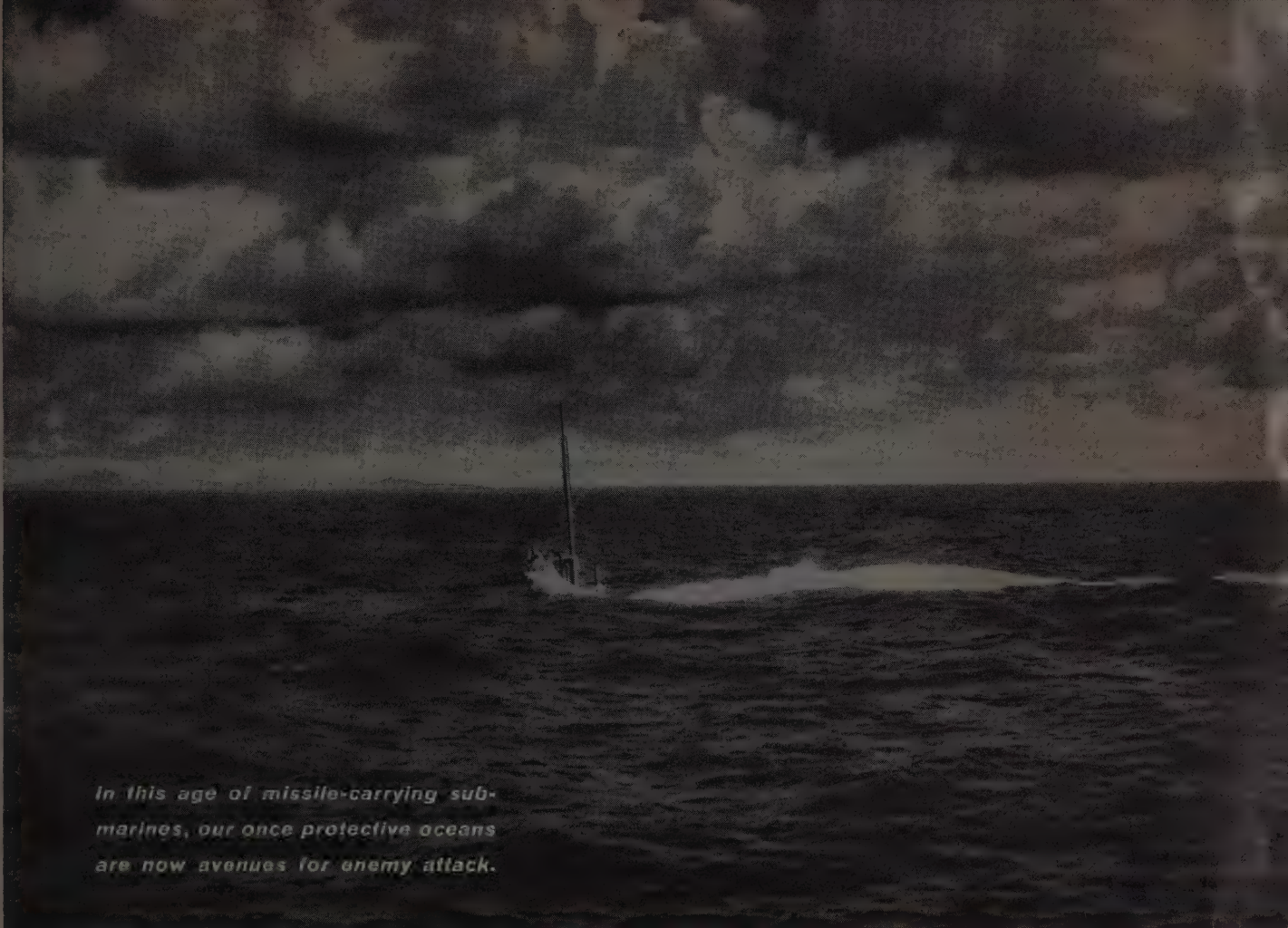
A complete technical manual preparation service devoted to designing, writing and illustrating quality technical literature.

- BROCHURES
- MILITARY HANDBOOKS
- PARTS CATALOGS
- MAINTENANCE MANUALS

For more information contact  
**MANUALS, INCORPORATED**  
3033 Excelsior Boulevard  
Minneapolis 16, Minnesota

Circle No. 240 on Reader-Service Card  
SPACE/AERONAUTICS





*In this age of missile-carrying submarines, our once protective oceans are now avenues for enemy attack.*

**circuit development — system planning engineers...**

## ***help nab hit-and-run divers***

Missile-packing subs able to "torpedo" Indianapolis from either ocean pose a sinister threat...call for even higher levels of detection sensitivity as well as totally new sub-hunting methods. Apparatus division of Texas Instruments has thousands of airborne submarine detector systems in the fleets of the world, but now is expanding its efforts to outstrip the new capabilities of the new generation of submersibles. Other active projects in this division include missile and space electronics, early warning, reconnaissance, airways control, and attack control. Any program you choose will be amply supported by the latest facilities and implemented by TI's ability to create basic components or complete systems.

TI's brisk, steady growth (20-fold over the past decade to a current \$90-million volume) creates corresponding needs for all levels of talent. Engineers, physicists... choose your design or production future —

**PROGRAMS:** advanced military systems studies — airborne early warning — airways control — antisubmarine warfare — attack-bomb navigation systems — countermeasures — engine instrumentation — missile systems — portable ground equipment — reconnaissance — space electronics.

**BUILDING-BLOCK EQUIPMENTS:** radar — infrared — sonar — magnetic airborne detection gear — digital-circuits — timers — telemetering — intercom — microwave — optics — detector cells — engine instruments — transformers — time standards — and other precision devices.

**come and grow with us...**

Hitch your wagon to the Lone Star... work at a plant within the city but away from downtown traffic... live within minutes of your work or your play — year-around recreational, amusement and cultural activities. Please contact —

**TEXAS INSTRUMENTS**  
**INCORPORATED**

6000 LEMMON AVENUE DALLAS 9, TEXAS

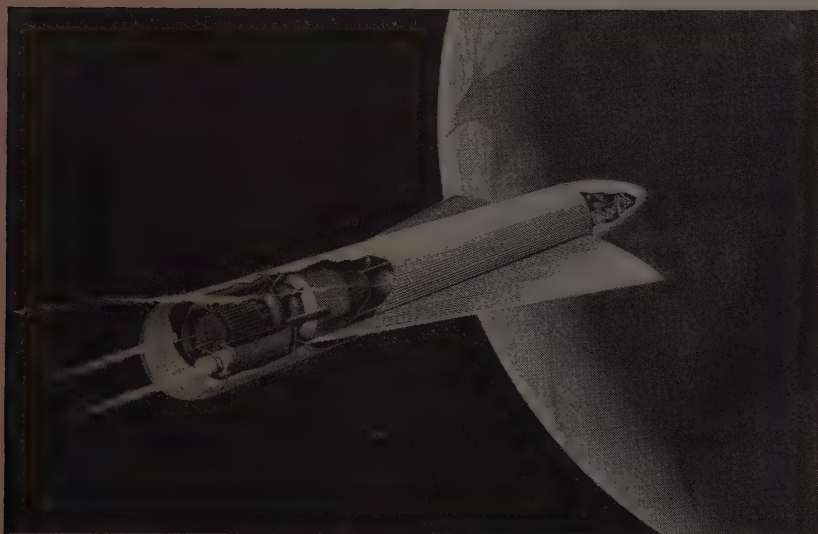


**Mr. John Pinkston**  
**apparatus division**



# COUNT DOWN!

*for the conquest of space*



## ROCKETDYNE ENGINEERS HAVE MADE MORE THAN 50 TRIPS TO THE NEIGHBORING PLANETS

Through the ship's viewing port looms a breathtaking sight—a gigantic red crescent spanning some 30° of deep black sky. A television camera, passenger on this strange new chariot, stares intently at a sight never before seen by man and beams home to Earth his first crude view of the planet Mars.

### From dream to drafting board

Less than a decade will pass before this age-old dream of man is realized. Bold steps toward such an exploration of Space are underway now. An experimental ion rocket engine will soon be placed in operation at Rocketdyne's Propulsion Field Laboratory in the Santa Susana mountains. From this research tool will come design data for the efficient, low-thrust freight engines for Outer Space. These engines will be capable of operating for months at a time, and will make pos-

sible extended reconnaissance of the Solar System and detailed studies of the phenomena of Space.

### But what of the journey itself?

Rocketdyne engineers have made more than 50 trips to the neighboring planets on huge computer machines. In these paper trips, they have studied the gravitational effects of as many as seven planets at a time. By watching closely the effects of such forces on their low-thrust ion vehicle they determined thrust programs to reach various planetary objectives. They showed the trip to Mars could be made with thrust to vehicle-weight ratios as low as 1 to 10,000.

### Testing in Space conditions

Rocketdyne has been at work on ion rocket engines since 1955. While many difficult design problems yet need to

be solved, extensive new facilities and three years of exhaustive studies are being applied to the job. Rocketdyne scientists will operate their experimental ion engine in simulated space conditions to unlock important answers to thrust chamber design, power conversion systems, nuclear heat sources, and propellants.

### Hardware for defense and science

Today the operating hardware in the field of high-thrust rocket engines is designed and built by Rocketdyne: propulsion systems for the Air Force's Atlas and Thor, and the Army's Redstone and Jupiter...and for scientific missions such as the Explorer satellites and the NASA space probes conducted by the Air Force and Army. Based on this unequalled experience, Rocketdyne is already probing far into the future. Engineers are already at



PROBING TOWARD THE PLANETS  
Heaved bodily into Space by the Rocketdyne-powered Thor first stage, the Pioneer starts on its 80,000 mile sortie toward the moon.

work on the next and succeeding generations of high-thrust rockets, and high-specific-impulse engines to supplement chemical rocket performance.

FIRST WITH POWER  
FOR OUTER SPACE

## ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

## DATA REVIEW

**REMOTE POSITIONING CONTROL**—Two bulletins, F 8537 and F 8342-1, from Barber-Coleman Co., Dept. S/A, 1400 Rock St., Rockford, Ill., describe magnetic amplifier control systems, for use in on-off, proportioning, or pulse-modulated floating temperature control applications as well as remote positioning and synchronizing systems.

Circle No. 308 on Reader-Service Card

**SERVOMOTOR**—Design and performance data on the smallest Size 8 servomotor available are contained in the four-page Data Sheet 1366, available from Helipot Corp., Dept. S/A, Newport Beach, Calif. The Model 8 SW 420, a 26 V, 400-cycle unit, is 0.840 in. long, weighs 1.1 oz., and has a stall torque of 0.25 oz-in.

Circle No. 309 on Reader-Service Card

**DROP TEST MACHINE**—A technical bulletin, on its Drop Test Machine, Model 30K, which provides shock forces in excess of 7 g's on specimens weighing up to 400 lbs., is offered by Aeroflex Corp., Dept. S/A, 34-06 Skillman Ave., Long Island City 1, N. Y.

Circle No. 310 on Reader-Service Card

**MINIATURE BEARINGS**—Details on its line of precision miniature ball bearings, including dimensions, tolerances, torque values, static and dynamic capacities and limiting speeds, are covered in the new six-page catalog supplement M1, available from Barden Corp., Dept. S/A, Danbury, Conn.

Circle No. 311 on Reader-Service Card

**NITROUS OXIDE**—A new eight-page brochure describing the types of nitrous oxide installations specifically designed for use in leak detection of pressurized systems is available from Ohio Chemical & Surgical Equipment Co., Dept. S/A, 1400 E. Washington Ave., Madison 10, Wis.

Circle No. 312 on Reader-Service Card

**GAS ANALYZER**—Beckman/Process Instrument Div., Dept. S/A, 2500 Fullerton Rd., Fullerton, Calif., announces the availability of a new, four-page bulletin, TC-4012, giving detailed information on the applications, features, principle of operation, and specifications of the Model 7C Thermal Conductivity Gas Analyzer.

Circle No. 313 on Reader-Service Card



# astronautics intelligence

**Biggest satellite yet put  
into orbit**

STANDARD ATLAS with extra fuel aboard managed to get into orbit with an apogee of 625 miles and perigee of 118 miles. It's by far the biggest satellite put up by man so far.

ORBITING ATLAS' weight of 8500-8700 lb is well over minimum weight needed for an "austere" manned capsule. Unofficial reports are that some sort of animal life aboard Atlas has survived, will be kept alive for at least two weeks.

Nose Cone engineers speculate that, toward the end of Atlas' orbiting life, the nose cone will be separated for a controlled re-entry attempt.

COMMUNICATIONS EQUIPMENT in the nose cone weighs about 150 lb. "Score" system contains receiver and transmitter for re-broadcasting messages received from the earth.

Project Score (Signal Communications by Orbiting Relay Equipment) is being run by ARPA. Atlas is the first of several planned launchings.

MINITRACK TRANSMITTER was assigned two frequencies—107.97 and 107.94 mc. Communications system was tied into four stations near Los Angeles, at Ft. Huachuca, Ariz., Ft. Sam Houston, Texas, and Ft. Stewart, Ga. Messages from any station could be relayed to the others.

PIONEER III MISSION to the moon and possibly the sun was not completed. But the Army space probe sent back exceptionally clear data on the radiation belt surrounding the earth.

Radiation was measured on both upward and downward legs of the trajectory, so that intensity can be compared for regions over different parts of the earth. Eventually scientists would like to launch straight probes up and down for radiation studies. This may even be done seasonally—to determine the variation (if any) in intensity over the year.

ARMY'S SPACE COMMUNICATIONS system still has not been checked out as a result of the incomplete Pioneer flight. The HF system is expected to have a range of some 500,000 miles.

PACIFIC MISSILE RANGE at Vandenberg AFB, Calif., will be the site of most of Project Discoverer satellite launchings planned by ARPA. It is expected a considerable number of launchings will be tried.

First series of Discoverer satellites will weigh about 1300 lb each. This includes weight of the second stage, which will orbit as an integral part of the satellite after burnout. Initial versions are designed to orbit for short periods of time at low altitude.

MAIN STAGE of Discoverer vehicle is a modified Thor IRBM. The second stage (from Lockheed) is new. It is powered by a Bell Hustler engine.

EARLY DISCOVERER LAUNCHINGS scheduled this year are designed mainly to test the vehicle itself, particularly its propulsion and guidance systems. Once the design has proved itself, a series of heavier satellites will be launched. These will contain biomedical specimens and live animals.

EVAPORATIVE COOLING SUIT is being developed to further man's tolerance of high temperatures. If results are successful, it may be possible for pilots to withstand much higher capsule re-entry temperatures than formerly thought possible.

Ventilated plastic film suit is worn under conventional pressure suit. Air circulated between the inner and outer suits reaches the pilot's skin through tiny pinholes in the plastic. It collects perspiration in the form of water vapor and seeps back out of the suit through larger holes in the plastic. Result: the body cools itself naturally by evaporation.

more on next page

**Nose cone re-entry  
experiment may come at end  
of Atlas' flight**

**Project Score comm system  
weighs 150 lb**

**Extensive, very clear  
radiation data gathered by  
Pioneer III on both  
legs of its trajectory**

**Most of ARPA's Discoverer  
satellite launchings  
to be made from  
Vandenberg AFB**

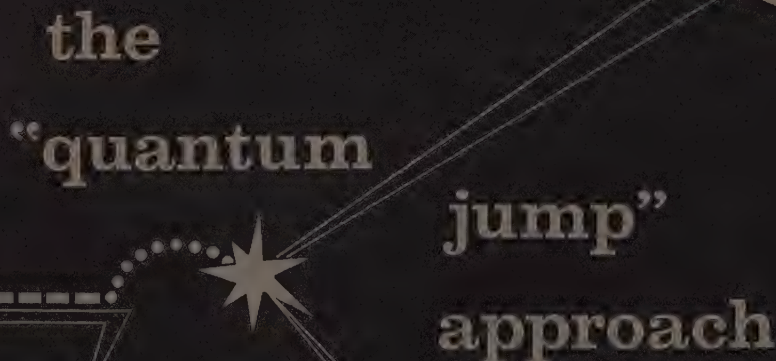
**Discoverer vehicle itself  
will be tested first**

**Ventilated suit may  
enable spacecrews to take  
higher temperatures**



SCIENTISTS - ENGINEERS

the  
"quantum  
jump"  
approach



NOT (-----) STEP-BY-STEP TRANSITION

## How Republic's Engineers & Scientists Attack Today's Missile, Aircraft and Space Problems

There's something in the environment at Republic Aviation that fires the imagination and sharpens the logical faculties.

You find it, at its quintessence, within the research groups, whose members have recently come up with a feasible design for a "Magnetic Pinch Plasma Engine" to operate in space. A design utilizing a novel application of basic knowledge in the field of magneto-hydrodynamics.

The same spirit of bold inquiry, of looking beyond the

immediate, conventional solution of a problem for new and better answers, permeates the entire professional staff. You'll find it in development engineers working on new missiles for new missions... in experimental engineers studying the behavior of a prototype aircraft. You'll find it in the metallurgical and electronics labs.

THE RESULT - "quantum-jump" advances in many technologies vital to the conquest of upper atmosphere and space flight.

*Engineers and Scientists who share Republic's views on Creative Problem-Solving are invited to discuss opportunities now open in the following areas:*

### THERMO, AERODYNAMICS

Theoretical Gasdynamics • Hyper-Velocity Studies • Astronautics Precision Trajectories • Airplane/Missile Performance • Air Load and Aeroelasticity • Stability and Controls • Flutter & Vibration • Vehicle Dynamics & System Designs • High Altitude Atmosphere Physics • Advanced Propulsion • Engineer Performance • Re-entry Heat Transfer • Supersonic/Hypersonic Wind Tunnels • Shock Tunnel • Plasma Tunnel • Magneto-Hydrodynamics • Ground Control Equipment

### ELECTRONICS

Inertial Guidance • Inertial Navigation • Digital Computer Development • Radar Design • Systems Engineering • Telemetry-SSB Technique • Information Theory • Doppler Radar • Countermeasures • Radio Altimeters • Radome & Antenna Design • Microwave Circuitry & Components • Receiver & Transmitter Design • Airborne Navigational Systems • Missile Checkout Systems • Missile Arming & Fusing • Jamming & Anti-Jamming • Miniaturization-Transistorization • Ranging Systems • Propagation Studies • Ground Support Equipment

REPUBLIC AVIATION is investing \$35,000,000 in bold new R&D Program designed to arrive at Major Breakthroughs in Transition from Aeronautics to Astronautics.



Send resume in complete confidence to:  
Mr. George R. Hickman, Engineering Employment Manager

**REPUBLIC AVIATION**  
Farmingdale, Long Island, New York

Circle No. 242 on Reader-Service Card opposite last page or send personal resume direct to address mentioned above. GIVE HOME ADDRESS

### ASTRONAUTICS INTELLIGENCE

VOLUNTEERS wearing the suit have been able to take 160 deg F continuously for three hours without any loss of work efficiency. Limit, or point of appreciably diminishing effectiveness, for men without "ventilated underwear" is about one hour.

Next step is to see just how high the temperature can be raised without impairing efficiency. Extremely high temperature tolerance may even be possible for a few minutes.

ELECTRIC impulse exercises may be the answer to keeping space travelers fit during lengthy confinement in cramped quarters. According to medics, it is possible to substitute electrically induced muscle contractions for normal exercise.

INITIAL trajectory of Pioneer III was picked up and followed by Collins tracking station in Puerto Rico. From there the probe's position was relayed to a larger station at Goldstone Lake, Calif., which then locked on to the signals from the low-power transmitter in the probe when it came over the horizon.

Collins teamed up with JPL to equipping the Goldstone Lake station. JPL provided the 85-ft dish and the pedestal and Collins the receivers, display units, telemetering, recorders, etc.

PLANET shots will be scheduled by the calendar as much as by technological advances. Assuming present rate of development is continued, best time for a Venus vehicle launching will be in June of this year. Next time chances of success will be as good will be September 1962.

OVER next 10 years, we will have only six good opportunities to send a space probe to Venus and only four for Mars.



# **HIS FIRST 707 LANDING...**

## **...BUT MIDWAY SIMULATOR INSTRUMENTS MAKE IT ALMOST ROUTINE**



Landing a Boeing 707 jet for the first time takes skill and thorough training. Today a new jet pilot faces this task with confidence for he has many simulated landings behind him . . . thanks to **MIDWAY** instruments.\*

**MIDWAY** Simulator Instruments realistically reproduce actual flight conditions — including emergency and bad weather situations. To meet stringent training standards, these instruments must be capable of many repeat performances at uniform high accuracy.

At **MIDWAY** no compromise is made with quality . . . for quality means reliability.

For information about **MIDWAY** instruments write to Publications Dept.

ENGINEERING DESIGN, PROTOTYPE DEVELOPMENT AND PRODUCTION  
OF CUSTOM PRECISION INSTRUMENTS FOR FLIGHT SIMULATORS  
GROUND-SUPPORT EQUIPMENT • MISSILE CHECK-OUT EQUIP-  
MENT • ELECTRO-MECHANICAL DEVICES • AVIONIC SYSTEMS

**MIDWAY**

Circle No. 243 on  
Reader Service Card  
Product Review  
Section

\*Midway Simulator Instruments are now helping to train commercial jet pilots for the Boeing 707, Convair 880, the DC-8, and Lockheed Electra.



# design progress

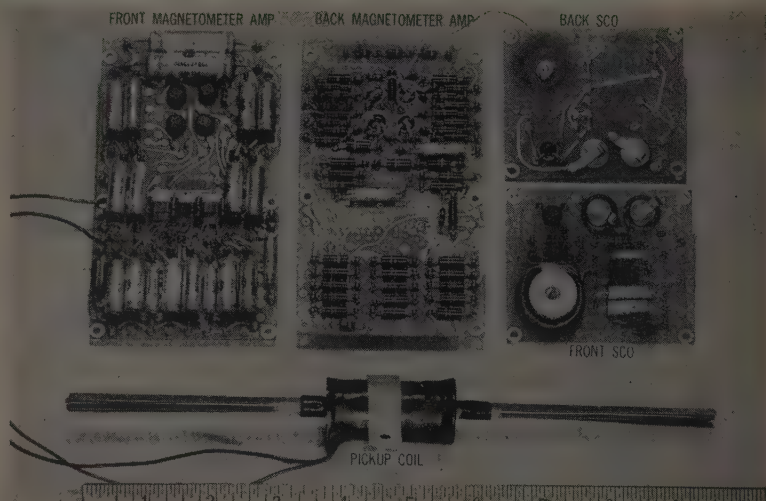
## Honeycomb housing for pioneer instruments

USAF'S PIONEER lunar probe moon, which streaked about 71,000 miles into space last Oct. 12, was fourth stage of a launch vehicle weighing about 104,500 lb. First stage was a Douglas Thor; second, an Aerojet-General liquid rocket; third, an Allegany Ballistics Lab solid rocket. Pioneer itself weighed about 85 lb. Its honeycomb fiberglass package and supporting structure had a weight of less than 15 lb. Instrument package was developed by Space Technology Laboratories, P.O. Box 95001, Los Angeles 45, Calif., weighed about 30 lb.

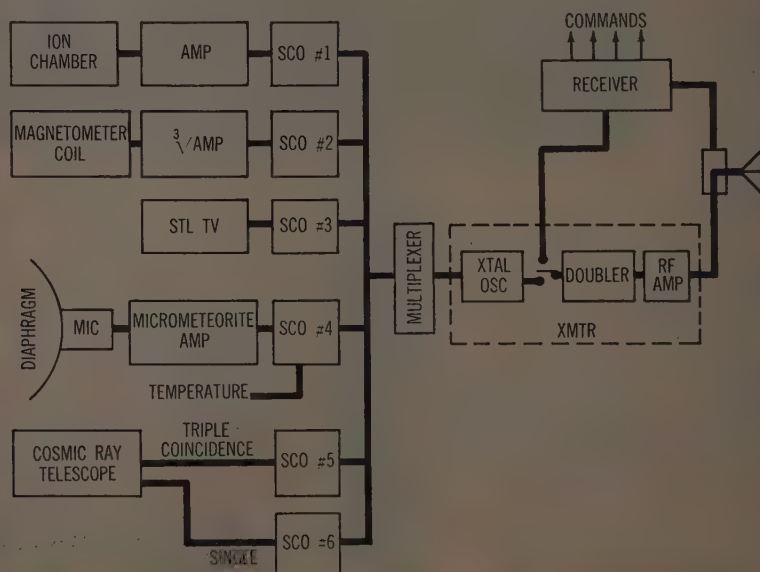
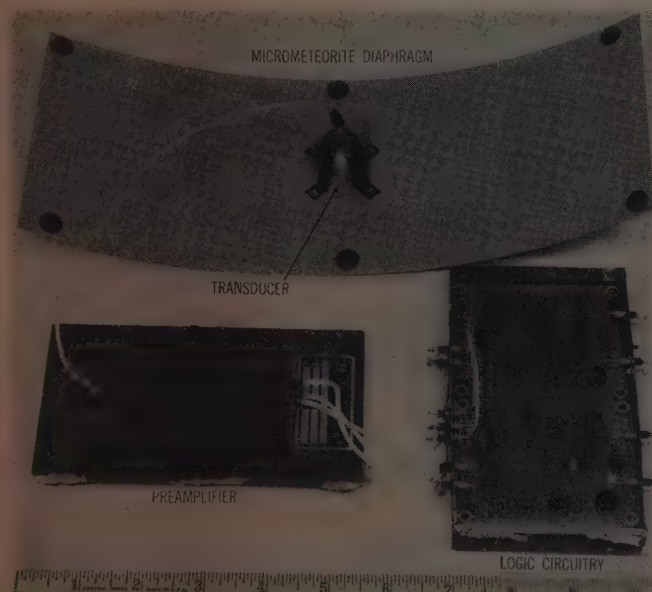
by Irwin Stambler, Engineering Editor



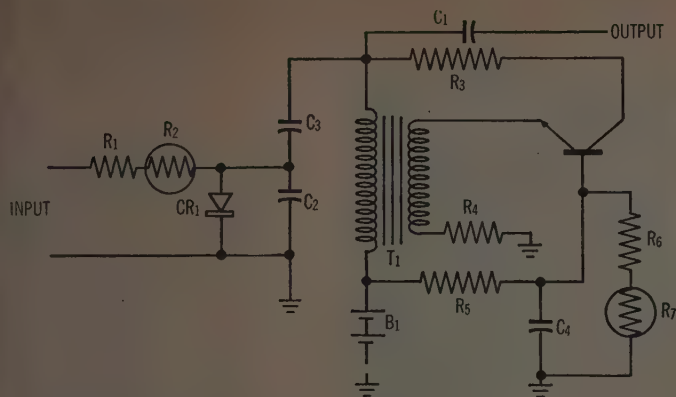
**PIONEER INSTRUMENTATION**—Package (above left, without cover) has Thiokol retro-rocket weighing about 35 lb. Above right: magnetometer circuitry. Below left: Elements of micrometeorite assembly. Its data involve only counting, so internal ambient



temperature can be multiplexed on top of it as shown in block diagram (below right). STL Microlock receiver is smaller than shoe box, can be acquired from ground to supply either Doppler readout (for which transmitter becomes transponder) or commands for verniers, retro-rockets, etc.



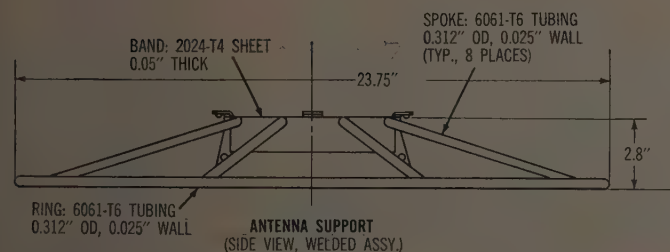
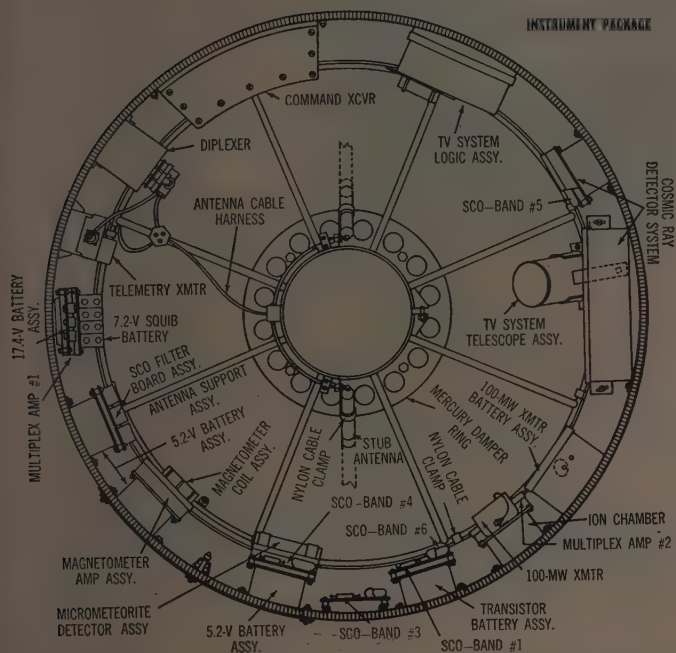




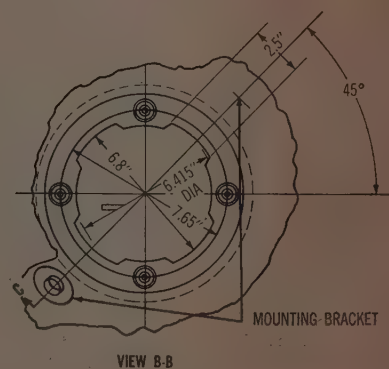
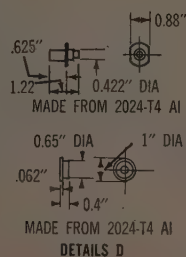
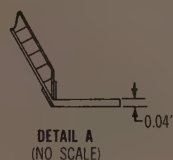
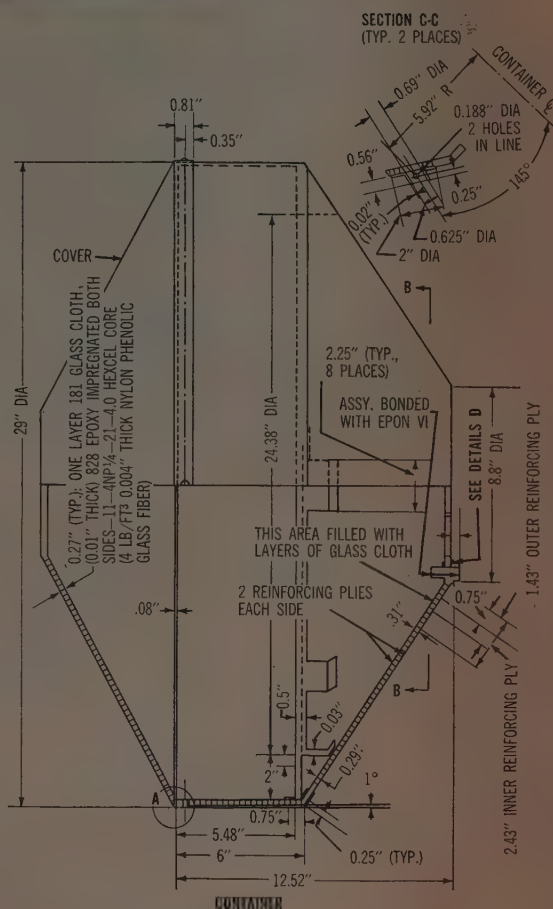
**SUBCARRIER** oscillator carried by Pioneer.



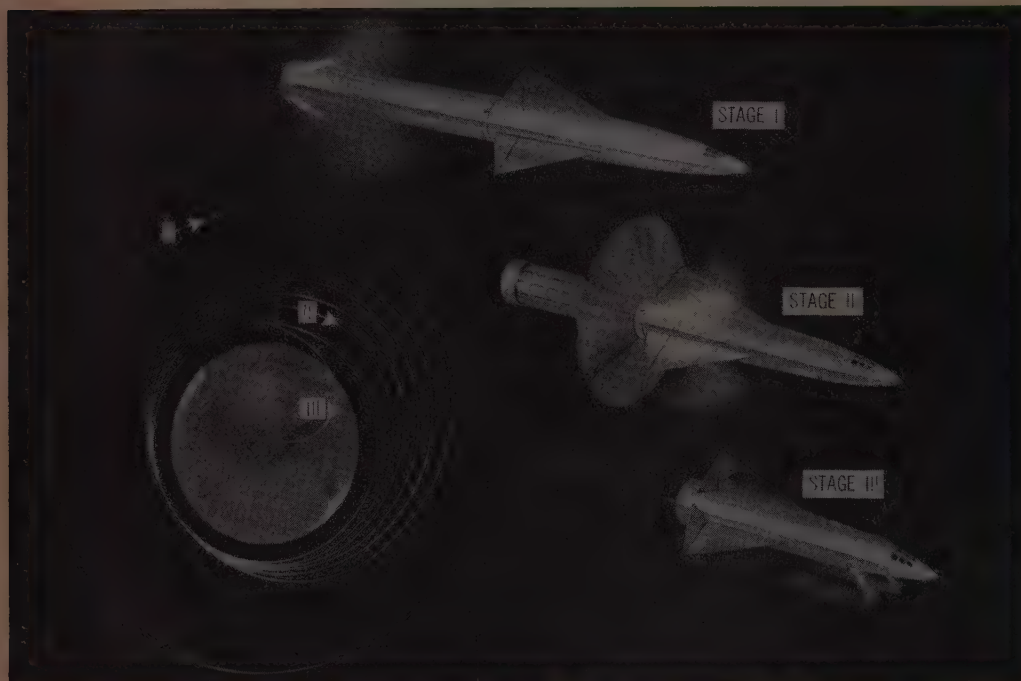
**PAINTED**, pressure-sensitive aluminum foil applied to container's outer surface formed blocking pattern for control of Pioneer's internal temperature. Pattern had to be changed daily while the vehicle waited for launch.



**INSTRUMENT** layout and structural design of Pioneer. Folded dipole antenna was installed on inner surface of cover. Honeycomb container was picked by STL engineers for minimum weight.







**FIGURE 1:** Combination of retro-rockets and drag devices might prove workable for satellite recovery. During Phase I, small retro-rockets near tail are used at high altitudes to change orbit ellipticity. When the vehicle has dipped into denser air, large, flaring drag device of Phase II causes the orbit to decay until it is nearly circular at under 100 miles altitude. During Phase III, larger retro-rockets are used for lift augmentation and deceleration to prevent spiral-in and excessive heating.

## Retro-rockets and drag devices teamed for satellite recovery

Pretty soon, satellite recovery will loom as large as satellite launching does right now. It's generally recognized that it will have to be done by means of retro-rockets. But just how are these going to work? Here is an article that answers this question—partly by pointing out that rockets can't do the whole job all by themselves.

by **F. W. Ross**, Chief of Aerodynamics, Solar Aircraft Co.\*

**T**HE problem of satellite recovery applies to just about all recoverable space vehicles that we can imagine as "reasonably" economical in operation: Even those among these vehicles that escape into space will have to go into an orbit before re-entering.

If retro-rockets are used for it, satellite recovery essentially turns into the reverse of the

launching process. In launching, most of the energy is needed to accelerate the satellite. Comparatively little must be expended to raise it to altitude. In recovery, most of the energy must be expended on deceleration. Only a little extra must be used to lower the satellite from 300 miles to the surface of the earth.

The kinetic energy for a satellite orbiting about a homogeneous spherical body of

\*Solar Aircraft Co., 2200 Pacific Hwy., San Diego 12, Calif.



mass  $M$  at a distance  $h$  above the surface is:

$$KE = kM/2(r_0 + h),$$

where  $r_0$  is the radius of the planet and  $k$  the universal gravitational constant from Newton's theory. The total energy for this case is:

$$TE = kM[1 + h_r/(1 + h_r)]/2r_0,$$

where  $h_r$  equals  $h/r_0$ .

Kinetic, potential and total energies here aren't influenced by such factors as air drag, propulsion efficiency, ellipticity, etc. They are determined entirely by the altitude of the orbiting mass. This is true of any motion in a central force field.

As Figure 2 shows, the magnitudes of the energies make satellite recovery a formidable problem. The amount of energy involved is over 19,000,000 ft-lb per pound of orbiting mass, or 24,400 btu/lb. The heat energy of a pound of hydrocarbon, such as gasoline, is only about 21,000 btu/lb. And an oxidizer with several times the weight of the fuel must be used to get this energy.

If the entire orbiting mass were hydrocarbon with the most favorable ratio of oxidizer and all of it were used with 100 per cent efficiency, there would be only enough energy available to slow down about 25-30 per cent of the mass. When we take account of the fact that there must be weight for structure and payload, we see that some form of staging is needed.

energy below 300 miles  
early all kinetic

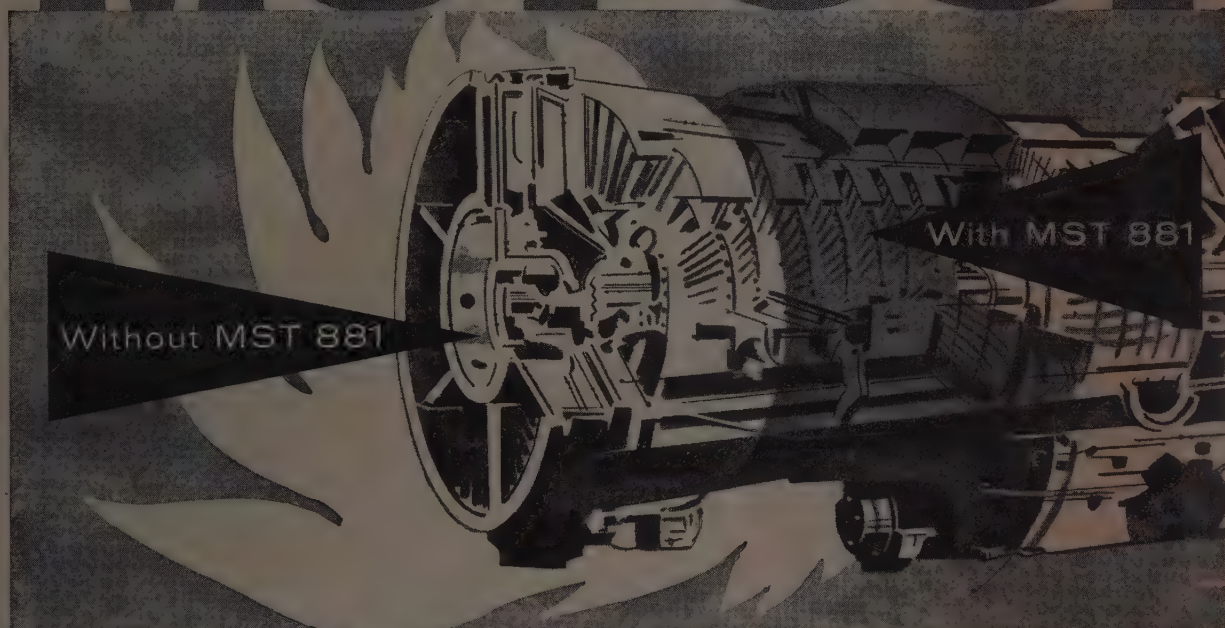
Figure 2 also shows that a satellite orbiting at high altitude — say, 2000 miles — requires only about 1.15 times more energy than one orbiting 200 miles. On the other hand, a satellite weighing 3000 lbs, as does Sputnik III, needs more than 100 times as much energy as a 30-lb satellite.

Note also that the total energy for altitudes below 300

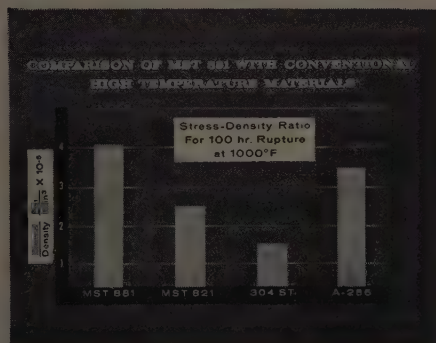
more on next page

## New Mallory-Sharon 1100° Titanium Alloy

# MST 881



## BREAKS THE HEAT BARRIER



Note high stress/density ratio of MST 881 at 1000° F., compared to MST 821 alloy, 304 and A 286 stainless steels.

Now, after 2½ years of intensive research, Mallory-Sharon has developed a new titanium alloy with elevated temperature properties far surpassing those of any existing titanium alloys.

At a temperature of 1000 degrees F., a level of increasing importance in the aircraft industry, MST 881 has more than twice the creep strength of any existing commercial titanium alloy. Even at 1100 degrees F., MST 881 will have only about 0.5% deformation at a stress of 25,000 psi.

What this means in terms of jet engine construction, for example, is illustrated above. The weight-saving advantages of titanium can now be obtained in additional stages of hot Mach 3 engines through use of MST 881.

Write today for technical data sheet on MST 881.

**MALLORY  SHARON**

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

Circle No. 244 on Reader Service Card in Product Review Section



# RENÉ 41 *fine* WIRE

**... almost too fine to see,  
too versatile to believe!**



- For use in the  
1200°-1800° F range
- Tensile strength  
to 425,000 psi

From Cannon-Muskegon — a major move in special metals development! Now the amazing properties of René 41 are yours to utilize in *fine-wire form*. This new vacuum-melted, high-temperature product is just .0015" in diameter . . . half the thickness of a human hair. One ton could circle the earth three times, four tons would reach the moon!

Yet thin as it is, René 41 fine wire has unusual strength. Under cold reduction, tensile strengths to 425,000 psi have been obtained. And even at 1800° F it maintains high oxidation resistance, exceptional tensile and yield strength.

René 41 fine wire is currently being used in the form of screens, filters, cables, strainers and casings for high-temperature applications.

René 41 and other vacuum-melted high-temperature alloys are also available in sheets up to 48" wide x 120" long, and in thicknesses down to .010. Bar stock is available up to 3" in diameter, and foil down to .001 in thickness.

Our metallurgists will furnish any help or data you may desire. Write Cannon-Muskegon.



**CANNON-MUSKEGON CORPORATION**

2800 Lincoln Avenue • Muskegon, Michigan, U.S.A.

**METALLURGICAL SPECIALISTS**

## SATELLITE RECOVERY . . .

miles is nearly all kinetic—it is nearly all due to the satellite's high speed, and only a small portion of it is contributed by altitude or the effect of gravity. This bears out our previous statement that, in launching, the problem is mainly one of accelerating the mass to orbital speed.

The essential difference between launching and recovery is due to aerodynamics. During launch, aerodynamic drag acts against the thrust, making it necessary to use more thrust to overcome this drag. For recovery, the drag works in the same direction as the decelerating thrust and reduces the required thrust.

When staging is used, the launching losses caused by drag are larger because they are, in part, determined by the size of the larger initial stage. For a re-entry vehicle, the "larger initial" stages operate at or near the altitudes at which the air drag is lowest. The direction of these two effects tends to increase the propulsion needs in both these cases.

### High altitude deceleration should be faster

Launching and recovery are closely similar in another respect: Less fuel is needed for launching if high acceleration are used to permit ejection of the initial stages at as low an altitude as possible. Conversely, for re-entry it's more efficient to decelerate faster at first before the initial stage gain speed through losing altitude. If this isn't done, the added energy (jet thrust) will have to be expended to decelerate this extra speed of the initial stages.

From this we can see that if retro-rockets are to be used as the sole means for recovery of a satellite from orbit, the re-entry vehicle would operate much as the launch vehicle did—but in reverse. The necessary propulsion units will have



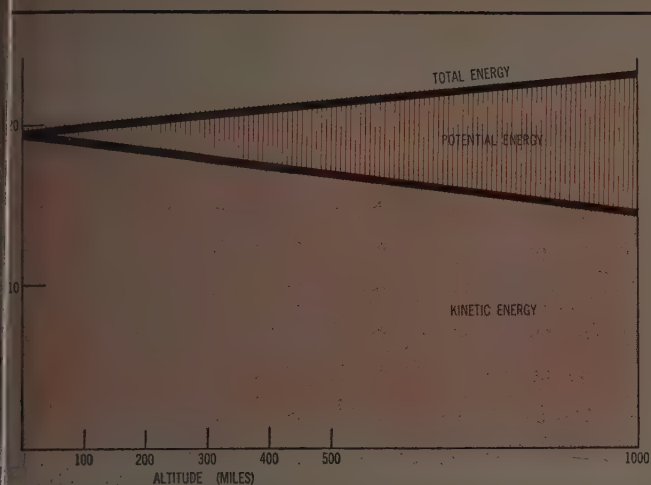


FIGURE 2: Kinetic, potential, and total energies of typical satellite orbiting above the earth's surface.

about the same relative magnitudes in both cases.

For Vanguard, a gross weight of 22,600 lb is needed to place about 220 lb in orbit, giving a launch-orbit weight ratio of about 100. For a return trip, therefore, the ratio of orbiting weight to recovered weight is also 100. Consequently, the overall launch-recovery weight ratio becomes 10,000. To recover a 1000-lb satellite solely by means of retro-rockets we would need an initial launch weight of 10,000,000 lb with present chemical fuels and staging methods. Obviously, recovery by retro-rockets alone is not what we are looking for.

We can, however, make use of air drag to obtain a workable recovery system (Fig. 1). The problem here is that, at higher altitudes, the air drag is

so low that appreciable loss of altitude takes days or months. At lower altitudes (50-100 miles and below), on the other hand, the drag offers too much resistance—the satellite spirals in rapidly and finally dives, building up high temperature as well as high acceleration. By using rockets in conjunction with drag devices, this problem can be solved.

At high altitudes, jets can be applied opposite to the orbit speed at apogee to increase the ellipticity and reduce the perigee to lower altitudes. There, with the aid of large drag 'chutes or balloons, the higher drag at perigee can be used to dissipate the orbital energy faster in the initial phases of recovery. The jet sizes and fuel energies needed to change the ellipticity are

more on next page

#### Comparative Recovery Energy Needs

	Mass & Total Energy Ratio to Earth	Radial Ratio to Earth	Equivalent Altitudes (miles)
Earth	1	1	300
Balloon	0.0123	0.2738	82
Parasails	0.107	0.5340	160.2
Parachutes	0.82	0.9720	292
Reentry Vehicle	317.7	10.92	2760

# What makes the

# Micropoise Relay

## Really New?



### A NEW MAGNETIC CONCEPT CREATES A NEW RELAY WITH

### OUTSTANDING IMPROVEMENTS

1. Vibration (100 to 2000 CPS at 15g)
2. Reduced weight (40% weight saving)
3. Reduced size ( $\frac{2}{3}$  the cube of competitive designs)
4. Withstands impact (100g --  $11 \pm 2$  milliseconds) making this new MICROPOISE RELAY ideal for missile programs, the ever increasing more exacting aircraft control requirements, and for highly reliable electronic computer applications.



A DIVISION OF

## Cook Electric Company

2700 Southport Ave., Chicago 14, Illinois

Diaphlex—Aircraft Components and Accessories.  
Cook Research Laboratories—Basic & Applied Research. Inland Testing Laboratories—Qualification, Environmental, Reliability and Radiation Testing.  
Magnilastic—Expansion Joints and Large Scale Metal Fabrications. Wirecom—Wire Communication Protection & Distribution Equipment. Electronic

Systems Division—Engineering and Production of Electronic Gear. Air mod—Modernization, Modification, and Maintenance of Aircraft. Nucleodyne—Engineering and Design of Technological Facilities. Cinefonics Inc.—Motion Picture Production. Canadian Diaphlex, Ltd.—Aircraft Components and Accessories.

Circle No. 247 on Reader Service Card in Product Review Section



comparatively small—air drag accounts for most of the dissipation.

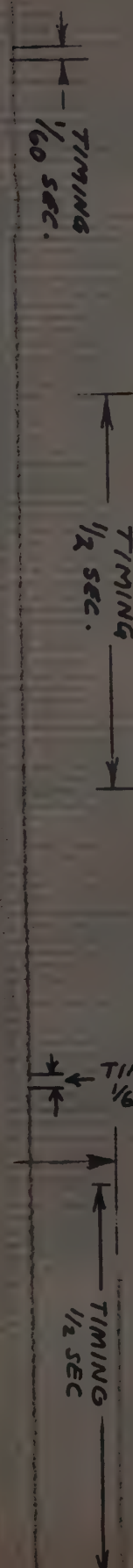
After the orbit has been decayed to nearly circular shape at about 35-50 miles altitude, the re-entry vehicle will tend to spiral in as drag increases. One way of preventing this spiraling might be to design the vehicle to provide lift. However, at the air densities and speeds involved here, aerodynamic lift is low and may be less than the drag.

Jets must again be used to keep the rate of descent low enough to eliminate spiral-in. By tilting the jets forward, the lift component can be held nearly constant, for the cosine of the angle of tilt will vary only very slightly from 1. This added deceleration reduces the heating factor and makes possible a steeper descent.

As a final note, observe that the energy requirements as stated in *Figure 2* and *Equation 2* are determined directly by the weight of the earth. If a satellite is orbiting around any other body, such as the moon, Mars, or Venus, at a proportionate height, the total energy—and hence the retro-rocket needs—are proportionately more or less, depending on the mass of the body.

As the table shows, a launch-and-recovery vehicle based on the moon would require about 1.23 per cent of the retro-thrust needed for comparable earth vehicles. For Mars, the retro-thrust needs are only 10.7 per cent of those for the earth. For Jupiter, though, they are enormous—317 times as much as for the earth.

The much lower retro-thrusts needed for the moon and Mars cases are important, since these bodies are thought to have little or no atmosphere. Hence re-entry will have to be done largely by means of retro-rockets without the aid of energy dissipation by air drag.—End



This is a record

WATER FLOW SYSTEM  
WATER FLOW PERFORMANCE TEST  
CHART SPEED 5"/SEC.  
5"/SEC.

ENCE

STATIC

STATIC REFERENCE

Unretouched Visicord® Record—actual size





Wyle Laboratories in El Segundo, California, have used a battery of four Visicorder consoles like the one shown below to run a series of tests on a vital missile component. In the Wyle test project the unique Visicorder consoles are easy to operate. Most parameters are low frequency, requiring response on the order of 5 to 60 cycles.

The two calibrator control panels in each of the Visicorder consoles accommodate 10 plug-in balance and matching units—designed to match tachometer generators, pressure transducers, thermocouples, expanded-scale voltmeters, etc., to the Heiland galvanometers.

## of a missile component



Tom Jackson, Wyle engineer, examines Visicorder record

Dick Johnson, Instrumentation Branch Head at Wyle Laboratories, says. "This system, I feel, is one of the most efficient instrumentation consoles in operation. Set up and calibration time has been reduced by the use of Visicorders by approximately fifty percent. This is due to the simplicity of operation and trouble-free performance. There are no inking pens to clean, high-gain amplifier maintenance, and so on, and we can also use these consoles together to form systems of more than six channels."

The HONEYWELL VISICORDER is the first high-frequency, high-sensitivity direct recording oscillograph. In laboratories and in the field everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics ... in any field where high speed variables are under study.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

**Reference Data:** Write for Visicorder Bulletin Minneapolis-Honeywell Regulator Co., Industrial Products Group, Heiland Division 5200 E. Evans Ave., Denver 22, Colo.

# Honeywell



Industrial Products Group

## books

**Metals for Supersonic Aircraft and Missiles.** This is the proceedings of the conference on Heat Tolerant Metals, held at the Univ. of New Mexico, Albuquerque, N.M., Jan. 28-29, 1957, jointly sponsored by the Univ. and American Society for Metals. American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio. \$7.50.

**Causes and Prevention of Corrosion in Aircraft,** by T. C. E. Tringham. Included in the areas covered in this book are the causes of corrosion, testing methods and methods of applying corrosion resistant coatings. Pitman Publishing Corp., 2 W. 45th St., New York, N. Y. \$5.75.

**Proceedings of the National Electronics Conference,** Hotel Sherman, Chicago, Oct. 7-9, '57. This contains some 100 papers presented at the meeting covering most major areas in electronic design. National Electronic Conference, 84 E. Randolph St., Chicago 1, Ill. \$7.50.

**Standard Aircraft Handbook,** by Stuart Leavell & Stanley Bungay. Intended for production workers, this includes tables on riveting, bolting standards, materials, etc. Aero Publishers, 2162 Sunset Blvd., Los Angeles 26, Calif. \$2.75.

**Graphic Science,** by T. E. French & C. J. Vierck. This comprehensive book provides the designer with both fundamental theory and a wide range of applications of engineering drawing, descriptive geometry and graphics. Such subjects as functional scales, nomography, graphic calculus, vector geometry and applied geometry are discussed. A glossary of technical terms and a series of standards tables are also included. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y. \$8.50.





project:

## FUELING THE THOR — FASTER



### FRI develops successful automated hookup and couplings for fast LOX and fuel transfer

Here, the problem was 5-fold. (1) Develop a flexible coupling for automated hookup. (2) Prevent leakage. (3) Protect vital internal parts from icing. (4) Provide high flow with minimum pressure drop. (5) Keep weight to a minimum.

**Flight Refueling, Inc. solved it.** The long experience of Flight Refueling, Inc. in developing, testing and manufacturing lightweight aerial systems, and the recent experience of designing components for the transfer of hydrocarbon fuels, LOX,  $H_2O_2$ ,  $N_2$ , mercury and other nuclear reactor coolants, as well as heated gases, has resulted in the successful completion of many unusual projects.

If you are concerned with *fast fluid transfer*, remember this—FRI has the engineering imagination to design complete lightweight systems, and manufacturing facilities to produce in quantities such components as valves, couplings, nozzles, fittings and portable tanks. Write for literature.



**Flight Refueling, Inc.**

FRIENDSHIP INTERNATIONAL AIRPORT • BALTIMORE 3, MD.

West Coast Representative: William E. Davis, Box 642, Inglewood, Calif.

Circle No. 248 on Reader Service Card in Product Review Section

## product index to advertising

**T**HIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements on which complete information was not available at the closing date (December 5) are not necessarily covered by these indexes.

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader-Service Card opposite page 167.

<b>A</b>		Decoders	113
APUs	16	Detection Systems, Infrared	113
Accelerometers	158	Directories	54
Actuation Systems	27	Disks	33
Actuators, General	131	Display Systems, Navigation	113, 121
Aircraft, Fixed Wing	39	Drives, Constant-Speed	61
Alloys			
Aluminum	44	<b>E</b>	
High Temperature	93	Elastomers	3
Sealing	33	Electronic Components	118
Amplifiers, Servo	113	Encoders	113
Antennas			
Airborne	82	<b>F</b>	
General	141	Fasteners	
<b>B</b>		Cold-Forged	132
Base Line Units	138	General	48, 64, 96, 117, 129
Batteries	53	Panel	63
Beacons, Radar	113	Quarter-Turn	31
Bearings		Films, Reproduction	78
Ball	8, 11, 37	Finishes	43
Needle	166, 168	Foil, Shielding	112
Roller	41, 168	Formers, Radial Draw	7
Blades	131	Fuel System Equipment	3, 27, 131
Bolts, Lock	131		
Braking Systems, Aircraft	27	<b>G</b>	
Bushings, Ball	115	Gages, Pressure	158
<b>C</b>		Generators	
Cable, General	56, 118	Brushless	108
Capacitors	119	Pulse	141
Cells, Fuel	3	Ground Support Equipment	3, 43, 57, 67, 92, 109, 138, 162, 186
Checkout Equipment	6	Guidance Systems	113
Chromalizing	167		
Clips	79	<b>H</b>	
Cloth, Tracing	164	Heat Exchangers	45, 92, 141
Clutches	59	Heaters	
Communications System Equipment	141	Ground	92
Compasses, Bow	68	Space	43
Computers		Heating Elements	79
Airborne	35	Hose	94
Engineering	89	Hydraulic System Equipment	16, 27
Contacts	33		
Control System Equipment		<b>I</b>	
Electric	27	Indicators, Test	152
Electronic	27	Infrared Equipment	141
Fuel	27, 131	Inserts	
Hydraulic	27	Lock	129
Mechanical	27	Threaded	117, 129
Pneumatic	27, 92	Inverters	46
Temperature	45		
Control Systems		<b>J</b>	
Fuel	116	Joints, Flexible	162
Test	61		
Coupling Systems	45	<b>L</b>	
Couplings		Limiters	107
Duct	92		
Fluid	186		
<b>D</b>			
Data Processing System Equipment	113		
Data Recording Systems, Ground	147		



<b>M</b>	
etic Components	113
rials	2, 32, 33, 44, 49, 167
Products, Sheet	50, 124, 165, 118
Clad	33
owave Components	113
les, Ground-to-Ground	29, 43
rs	
stant-Speed	109
actional-HP	27
nchronous	109
<b>N</b>	
gation System Equipment	113, 125
er Fuel	131
chor Cap	129
rrel	129
ng Channel	129
ck	129
ck	96
ft-Locking	48
<b>O</b>	
el Systems	192
ts, Oxygen	183
ren, Liquid	55
<b>P</b>	
is, Test	146
ils	69
uling	68
ics	165
ng	160
s	32, 76
matic System Equipment	27, 92
er Supplies	
	54
agnetic	113
nsistorized	113
orplants, Rocket	174
er Units, Hydraulic	16
urization-Dehydration Units,	
ound	16
urization System Equipment	16
uction Equipment &	
oods	12, 77, 160
el	27
and	45
<b>R</b>	
er Equipment	141
naissance System Equipment	141
ys, Time Delay	60, 80
rs	131
er, Silicone	32
<b>S</b>	
twich, Stainless Steel	
neycomb	2
ers	68
ws, Actuator	47
	13, 106
le, Laminated	82
cers, Exhaust	57
one Parts	124
one Sheet	124
lator Instruments	177
ing	52
rometers, Frequency	84
ge, Silicone	124
Stainless	50
orts, Duct	92
ches	
rmetic	30, 120, 121
icator	121
y	120
yboard	81
nit	99, 121
ulti-Pole	79
nel	81
ssure	105, 116
shbutton	121
tary	120, 121
aled	121
ock	120, 121
minature	99
lemetering	121
rminal	120
ggle	81, 120
hros	109
<b>T</b>	
ometers	36
s	
ound Fuel	3

Oil	45
Test Equipment	61, 84, 112, 146, 152
Test Units, Environmental	146
Thermometers	158
Tires, Aircraft	5
Transducers, Pressure	112
Transistors	83
Tube Cooling Unit	16
Tubing	33, 34, 52, 118
<b>V</b>	
Valves	
Ball	154
Bleed	45
Bypass	45
Check	79
Explosive	45
Fuel	27
General	131
Pneumatic	27
Pressure	45
Rupture	45
Solenoid	45
Thermostatic	45
Throttle	158
<b>W</b>	
Windings, Potentiometer	106
Wire	33, 118, 138
Wrenches, Torque	12

#### Service Index to Advertising

Hotel Accommodations	112
Manuals	172
Production	
Brazing	60
Castings	167
Electronic	141
General	113
Subsystems	62
Systems	2, 162
Reliability Evaluation	141
Research & Development	
Airframes	2
Control Systems	2
Countermeasures, Electronic	141
Electronic	2
Ground Support Equipment	2
Subsystems	62
Systems	62
Telemetering	2
Test Equipment	2
Systems Management	2, 15
Testing	104

#### Employment Opportunities Index to Advertising

12, 15, 86, 90, 98, 101, 122, 144

PICTURE CREDITS: Cover, p. 4—Sperry Gyroscope; pp. 22-23, 77-81—S/A; pp. 24, 82-87—Sperry Gyroscope; pp. 25, 84-104—S/A; Sperry Gyroscope, Sylvania Electric Products, General Electric, Philco, USAF; pp. 26, 88-93—Aerojet-General; pp. 28-36—Space Technology Labs., Glenn Plasmadyne, Aero Mfg.; pp. 38-45—Du Mont Labs.; pp. 46-54—Northrop Aircraft; pp. 56-62—USAF; pp. 138-141—Northrop Aircraft; pp. 142-149—Boeing Airplane; pp. 150-154—Cannon Electric, Hadley, Permaluster, General Electric; pp. 178-179—Space Technology Labs.; pp. 180-184—Solar Aircraft; p. 190—USN.

**COLLECTIONS**  
For the Industry  
**ALL OVER THE WORLD**  
Airline and Aeronautical  
Accounts Receivable  
No Collections—No Commissions  
STANDARD ACTUARIAL WARRANTY CO.  
220 West 42 St., N. Y. 36, N. Y.  
LO 5-5990

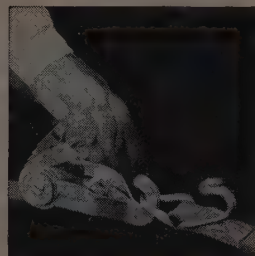
**BARGAINS GALORE** at the Institute of Surplus Dealers 9th Annual Trade Show, January 25 to 28, 1959 at the N. Y. Trade Show Bldg., 500 8th Ave., N.Y.C. Government & Industrial Surplus for Sale. The only trade show that helps all industry to dispose of surplus inventory. Plan to attend! You'll profit!

## Versatile Ratchet Tie-Down Buckle Speeds Manufacturing, Simplifies Shipping

FOR DOUGLAS AIRCRAFT COMPANY



At Douglas Aircraft, components of an A-3D Bomber wing section are positioned with the Aeroquip Ratchet Tie-Down Buckle.



The Aeroquip Ratchet Tie-Down Buckle works like a miniature winch, holds tension.

Tie-down straps using the Aeroquip 5000-lb. Ratchet Buckle permit quick, easy handling of parts and equipment. Operating as a miniature winch, the Ratchet Buckle can introduce strap tension up to 500 lbs. manually. Used with any length webbing, it allows infinite strap adjustment and quick release. Also available in 10,000 lb. model. Mail coupon below for full details.



Transporting a disassembled Douglas A-4D Bomber is simplified by using Aeroquip Ratchet Tie-Down Buckles to secure components.



*General* **LOGISTICS**  
A DIVISION OF **Aeroquip** CORPORATION

2929 Floyd Street, Burbank, California

SA-1

Please send me ☐ full details on Ratchet Tie-Down Buckle ☐ complete new General Logistics catalog.

Name \_\_\_\_\_  
Title \_\_\_\_\_  
Company \_\_\_\_\_  
Address \_\_\_\_\_  
City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

Circle No. 249 on Reader Service Card in Product Review Section



# ATTENTION READERS

Have you read the important publisher's message appearing opposite the inside front cover?

If not, we hope you will do so before filing this issue.

It describes a change in format effective with the February edition.

We look forward to hearing from you about this move to make **SPACE / AERONAUTICS** even more useful to you.

## advertisers' index

A		General Electric Co.	
A.G.A. Div.; Elastic Stop Nut Corp. . . . .	80	Heavy Military Electronics Dept. . . . .	18
Airborne Accessories Corp. . . . .	119	Light Military Electronics Dept. . . . .	18
AiResearch Mfg. Co. . . . .	98	General Logistics Div.; Aeroquip Corp. . . . .	18
Alina Corp. . . . .	152	General Mills, Inc. . . . .	18
Allied Research Prods., Inc. . . . .	49	General Motors Corp. . . . .	18
Aluminum Co. of America . . . . .	44	Delco Radio Div. . . . .	18
Amchem Prods., Inc. . . . .	189	Hyatt Bearings Div. . . . .	40
American Chain & Cable Co. . . . .	56	New Departure Div. . . . .	18
American Super-Temperature		Saginaw Steering Gear Div. . . . .	18
Wires, Inc. . . . .	118	General Precision Laboratory, Inc. . . . .	18
AMP, Inc. . . . .	94, 95	Gits Bros. Mfg. Co. . . . .	18
Amphenol Electronics Corp. . . . .	108	Goodrich Co., B. F. . . . .	18
Armo Steel Corp. . . . .	50	Goodyear Tire & Rubber Co., Inc. . . . .	18
Armour Corp. . . . .	106	Groov-Pin Corp. . . . .	18
Automotive & Aircraft Div. . . . .	56		
Avco Mfg. Corp.; Crosley Div. Second Cover			
Avion Div.; A C F Ind., Inc. . . . .	113		
B		H	
B & K Instruments, Inc. . . . .	84	Hallicrafters . . . . .	18
Barber-Colman Co. . . . .	134, 135	Hart Mfg. Co. . . . .	18
Electrical Components . . . . .	164	Haydon Co., A. W. . . . .	18
Barco Mfg. Co. . . . .	162	Heiland Div. . . . .	18
Barden Corp., The . . . . .	37	Minneapolis-Honeywell . . . . .	184, 185
Bath Co., The Cyril . . . . .	77	Hetherington, Inc. . . . .	18
Bendix Aviation Corp. . . . .	142, 170	Hewitt-Robins . . . . .	18
Montrose Div. . . . .	33	Hickok Electrical Instrument Co., The . . . . .	18
Bishop & Co., J. . . . .	97	Hunter Mfg. Co. . . . .	18
B J Electronics; Borg Warner Corp. . . . .	148	Hyatt Bearings Div. of GMC . . . . .	40
B.M.B. Sales, Ltd. . . . .	105	Hydro-Aire, Inc. . . . .	154, 155
Bristol Co., The . . . . .	118	Hydromatics, Inc. . . . .	154, 155
Bud Radio, Inc. . . . .	136		
Bulova Research & Development Labs. . . . .	107		
Burdy Corp. . . . .			
C		I	
Cannon Electric Co. . . . .	76	Intl. Nickel Co.; Primary Nickel Sales . . . . .	18
Cannon-Muskegon Corp. . . . .	182	Intl. Rectifier Corp. . . . .	18
Century Electronics & Instruments, Inc. . . . .	66	Intl. Resistance Corp. . . . .	18
Chandler-Evans . . . . .	116		
Chandler Products Corp. . . . .	152		
Christie Electric Corp. . . . .	54		
Chromalloy Corp. . . . .	167		
Cincinnati Sub Zero Products . . . . .	146		
Clifton Precision Prods. . . . .	123		
Connecticut Hard Rubber Co. . . . .	32		
Consolidated Diesel Electric Corp. . . . .	103		
Consolidated Electrodynamics Corp. . . . .	61		
CONVAIR, A Div. of			
Gen. Dynamics Corp. . . . .	Fourth Cover		
Cook Electric Co. . . . .	183		
Cornell Aeronautical Laboratory, Inc. . . . .	12		
D		J	
Dalic Metachemical, Ltd. . . . .	160	Jack & Heintz, Inc. . . . .	18
Delco Radio Div. of GMC . . . . .	83	James Pond Clark . . . . .	18
Deutsch Co., The . . . . .	32	Jet Propulsion Lab. . . . .	18
Donner Scientific Co. . . . .	158	Calif. Inst. of Technology . . . . .	2
Dorne & Margolin, Inc. . . . .	82		
du Pont de Nemours & Co., E. I. . . . .	78		
E		K	
Eastern Industries, Inc. . . . .	16	Kaynar Co., The . . . . .	18
Elastic Stop Nut Corp. . . . .	129	Kearfott Co., Inc. . . . .	18
Electro Data Div.; Burroughs Corp. . . . .	89	Kemet Co.; Div. of Union Carbide Co. . . . .	18
Electro-Flex Heat, Inc. . . . .	79	Keuffel & Esser Co. . . . .	68
Electro Products Laboratories . . . . .	14	Koppers Co., Inc. . . . .	18
ElectroSnap Corp. . . . .	99		
Elgin Metalformers Corp. . . . .	146		
Ellis & Watts Prods., Inc. . . . .	168		
Endevco Corp. . . . .	156		
ERCO Div.; A C F Ind., Inc. . . . .	139		
Ex-Cell-O Corp. . . . .	131		
F		L	
Faber-Castell Pencil Co., Inc., A. W. . . . .	69	Laminated Shim Co. . . . .	18
Firth Sterling, Inc. . . . .	93	Lee Hotels . . . . .	18
Flight Refueling, Inc. . . . .	186	Leonard Co., Wallace O. . . . .	18
Fluid Regulators Corp. . . . .	140	Linde Co.; Div. of Union Carbide Co. . . . .	110, 111
Formsprag Co. . . . .	58, 59	Lockheed Aircraft Corp. . . . .	110, 111
G		M	
Garrett Corp. . . . .	98	Magnavox Procurement Div.;	
		Gov. & Ind. Div. . . . .	18
		Magnetic Amplifiers . . . . .	18
		Mallory Sharon Metals Corp. . . . .	18
		Manuals, Inc. . . . .	18
		Marman Div.; Aeroquip Corp. . . . .	86
		Marsh Corp., Jas. P. . . . .	18
		Martin Co., The . . . . .	42
		Martin Co., The Denver Div. . . . .	18
		Mayer's Grand Guide . . . . .	18
		McDonnell Aircraft Corp. . . . .	18
		McGill Mfg. Co., Inc.; Bearing Div. . . . .	18
		Microphase Corp. . . . .	18
		Micro Switch, Div. of Minneapolis-	
		Honeywell Regulator Co. . . . .	120, 121
		Midway Aircraft Instrument Corp. . . . .	17
		Miniature Precision Bearings, Inc. . . . .	18
		Misco Precision Casting Co. . . . .	18
		Missiles & Space Systems Div. . . . .	12
		Monsanto Chemical Co. . . . .	20
		Motorola Communications &	
		Electronics, Inc. . . . .	114, 115
		Mueller Electric Co. . . . .	18
H		N	
		New Departure Div. of GMC . . . . .	11
		New York Air Brake Co., The Third Cover	



American Aviation	86, 125, 138
Acetics Div.	39
mbus Div.	15
Angeles Div.	104
les Div.	174, 190
edyne Div.	67
op Aircraft, Inc.	

Chemical & Surgical Equip. Co.	170
Mfg. Co., John	36

Scientific Co.	106
d-Bell Technical Prods.	35
Seal Co.	100
ion Mica	112
ment Filter Corp.	137
or Prods., Inc.	145

on, Inc.	169
os-Manhattan, Inc.	12
on Mfg. Co.	150
o Aviation Corp.	130
flex Corp.	176
y Bearing Co.	98
	91

w Steering Gear Div. of GMC	47
n Co.	147
nds Aerocessories, Inc.	163
ns Fastener Corp.	65
n Tools Corp.	162
o Div.; South Chester Corp.	31
est Products Co.	8
Thermostat Div.	
ts & Controls Corp.	30
er, Inc.; J. S.	126
rd Pressed Steel Co.	51
s Mfg. Co., Inc.	96
ant Co., P. A.	159
lectric Corp.	12
or Tube Co.	153
e Combustion Corp.	34
rol Aircraft Auto Div.	
s Development Corp.	92
	90

Instrument Corp.	112
mputing Corp.	161
namics	19
Instruments	173
o Electric Co., Inc.	138
son Fiber Glass Co., H. I.	165
son-Ramo-Wooldridge, Inc.	149
on Industries, Inc.	115
gton Co., The	166
end Co.	64
Electronics Corp.	144

Switch & Signal Div.;	
tinghouse	160
l Aircraft Corp.	
siles & Space Systems Div.	122
l Aircraft Prods.	45
Metals Div.; Kelsey-Hayes Corp.	157

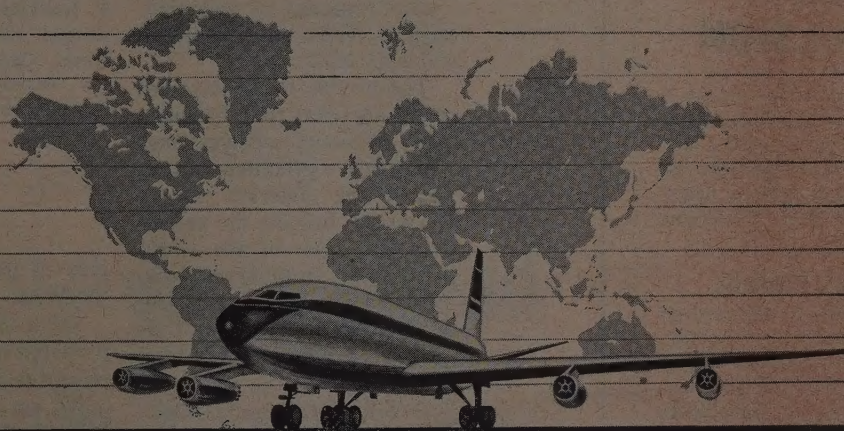
x Corp.	52
s, Inc.; Div. of Sperry Rand	63

Colmonoy Corp.;	
nless Processing Div.	60
ngton Steel Corp.	148

ey Electric Corp.	53
-------------------	----

# Amchem Alodine... industry standard for the jet age

## ... chemical conversion coatings for aluminum

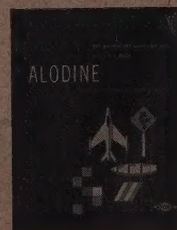


Jet aircraft fly higher, faster, farther than their piston-engined predecessors. Achieving this obvious superiority will require new levels of consistently maintained protective standards for parts and assemblies. • For that reason, fabricators of aircraft and aircraft parts continue to specify Amchem Alodine. Fifteen years of leadership and experience have made Amchem Alodine the industry standard for chemical conversion coatings for aluminum. Wherever it is used, Amchem Alodine has justified that use by improving the corrosion resistance and increasing paint bonding characteristics of aluminum surfaces. • Whether your activities involve conventional aircraft, jet age aircraft or missiles, it will pay you to investigate how Amchem Alodine produces low cost, more efficient chemical conversion coatings for your aircraft aluminum products.

Write for Bulletin 1424A describing the specific applications of Amchem Alodine. Contains handy Selection Chart to help you choose the Alodine type suited to your needs.



# AMCHEM ALODINE



Amchem Alodine is another chemical development of Amchem Products, Inc., Ambler, Pa. • Formerly American Chemical Paint Company Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont./Amchem and Alodine are registered trademarks of Amchem Products, Inc.





Help us solve  
the problems of

## ION PROPULSION

Our Advanced Design Group is seeking engineers and scientists to work on low-thrust propulsion systems that will make possible the manned exploration of Outer Space. These are a few of the challenging positions:

### Theoretical Physicist

Experienced in the field of particles physics, magneto-hydro dynamics, and plasma physics comparative performance of electrical propulsion systems, new methods of developing thrust from electrical propulsion systems, and direct conversion processes.

### Chemical Physicists

To make studies on propellants for ion propulsion. Experienced in electronics, atomic physics, and physical chemistry.

### Physicists

Primary activities will be in the field of ion sources and high vacuum techniques. Experienced in particle accelerators, ion sources, and electronics.

### Electrical Engineer

Analysis of electrical power generators, preliminary stages designs of permanent magnet, AC induction and electrostatic generators.

Please write: Mr. F. A. Jamieson, Engineering Personnel Dept., 6633 Canoga Avenue, Canoga Park, Calif.

**ROCKETDYNE** 

A DIVISION OF NORTH AMERICAN AVIATION, INC.  
FIRST WITH POWER FOR OUTER SPACE



## readers' round table

### We must cut down development time!

**T**HE West today is challenged as was the great Roman civilization just before its decline and fall.

Our response to that challenge is feeble. It is confused and contradictory.

The trouble is, we have not really analyzed the challenge. Look at Soviet achievements:

- Once a primitive, largely agricultural, illiterate nation, Russia has become the second industrial state of the world in 40 years. In this period she has been ravaged by war and revolution. Yet her rate of industrial expansion exceeded our own.

- Militarily, Russia is equal, perhaps superior, to the West.

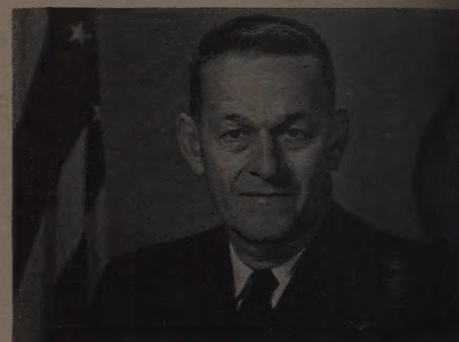
- Russia has produced a very large intellectual elite in all fields except the humanities. She seemingly has an inexhaustible reserve of scientists, engineers, and technicians. Quite as important, there are great numbers of linguists who, among them, command the languages of the world.

- Russia's people, as a whole, are imbued with a fierce patriotism and sense of mission. Whatever their sufferings, they are convinced that Russia represents the wave of the future.

- Africa and Asia have been penetrated by Soviet aid and investment faster than by ours. The conditions for Soviet help appear to these peoples more favorable.

- The Reds and their satellites proceed with a higher de-

**REAR ADM. JOHN T. HAYWARD**, Assistant Chief of Naval Operations for Research & Development



gree of integration than does the West.

What are we, as free men, prepared to do and *sacrifice* to meet this challenge?

To get a feel for the problem, we must define just what national strategy is. It is the use by a country of economic, political, psychological, and military forces to reach national objectives.

Note that our strategy must be more than just military. Mere reorganization of the Defense Dept. isn't going to bring everything into order.

*We must have a clearly spelled out national policy.* This must identify the global interests of vital national concern. We must be prepared to fight *any type* of war against the Sino-Soviet coalition—with or without allies, and without waiting for the U.N. to determine that the Reds are guilty of "aggression."

From this starting point we can go on.

We need an R&D program aimed at definite, long range objectives. Now, we can't have everything we want. So we must have a selective process.

Mistakes made in this selection process are largely responsible for development time problems. Anyone can set up an operational requirement. But if it doesn't make sense in terms of the present and

future state of the art, you pay a penalty in development time.

To get a reasonable program we must ask ourselves:

- Are the essential weapons on hand or in development?

- Are we thinking of or pursuing more ways to meet a given situation than are needed?

- Are the development times allowed for new weapon systems reasonably well matched to the state of the scientific and technical arts?

- Are the performance gains great enough to warrant a new system?

- Can the existing systems be modernized to produce an equal gain in performance at less cost?

- Are the requirements unnecessarily complex, so that we will end up with an expensive system?

- What is the threat for the task you are trying to meet in the time you have to develop your system?

There are many more questions. While the best technical answer may not always be the best policy, those who make policy must know the best technical answer.

A look at the strategic bombardment missiles quickly shows that all the questions were not answered. In some cases they weren't even asked.

Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

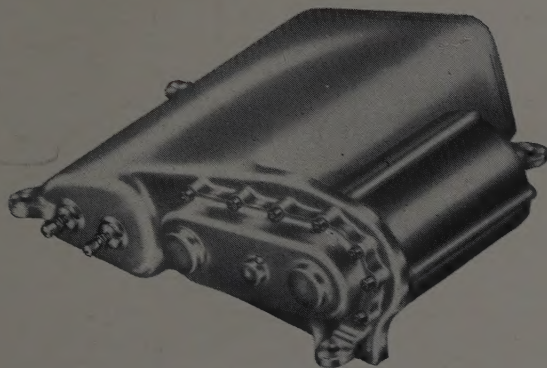


# Stratopower

## can't afford to stay in step-

## We have to stay ahead...

## years ahead in hydraulic development



The development process can only be shortened by careful planning and work in a selective process before the decision is made to go ahead. Let's look at the situation the Navy faces. The biggest problem today is the submarine-missile combination. Our success with Polaris shows clearly that this weapon system requires the most urgent requirements for a deterrent. It is flexible. It is secure, independent on foreign aid. We in the Navy, however, would be first to say it's a part of the overall deterrent position.

The Red missile launchings are a big threat to the U.S. and its allies. So the anti-submarine problem is high on the list.

Let me call your attention to the fact that the Russian bloc is equipped with modern weapons. If our aircraft are to compete in the air over the sea or on land, they must be modern. As long as the manned airplane is with us, the aircraft carrier will be here. The decision on the sea as on the land rests with the decision in the air.

In a review of events since 1945 and the situations that have faced our armed forces, we get some idea of the threat and the problems that we face in the future. Our weapon systems must be such that they can handle the various problems across the whole spectrum of warfare as it exists and as it will exist in the future.

This calls for great selectivity in choosing our weapon systems. It calls for short development times. We cannot afford seven years as in the past.

When we answer the questions we have posed, we should make decisions and cut down development time. I don't think this will happen overnight. But let me assure you that we in the Navy R&D business are going to do our best to make it happen as soon as possible.—End

STRATOPOWER keeps years ahead in hydraulic development by advanced theorizing, advanced research and testing ... and with the most advanced precision production facilities in the world. Here, for example, is a STRATOPOWER Hydraulic Package being built for a new missile project ... calling for "years ahead" hydraulic technology.

STRATOPOWER Hydraulic Packages and Systems are perfect examples of being "made for each other." They contain everything you need, including specified performance. Reservoirs, accumulators, valves, pumps, motors and even plumbing, are all mated into a smoothly functioning unit.

The heart of these Packages and Systems is the constant or variable displacement STRATOPOWER Hydraulic Pump.

Models are available to operate dependably up to 450° F., and at exceptionally high speeds.

The advanced designs of STRATOPOWER Hydraulic Pumps are made practical by precision manufacturing that makes watchmakers' standards seem clumsy by comparison. 50 millionths of an inch are tolerances found in production models. Specify STRATOPOWER Pumps, Motors, Packages or Systems, and you, yourself, take a giant step ahead of the competition.

**WRITE TODAY:** See how your hydraulic power application is best fulfilled by STRATOPOWER Hydraulic Pumps, Packages and Systems ... it's a step in the right direction!

**WATERTOWN** DIVISION  
THE NEW YORK AIR BRAKE COMPANY

STARBUCK AVENUE

WATERTOWN • N. Y.





In building, flight-testing and further developing the Atlas ICBM for the U.S. Air Force, **CONVAIR-Astronautics** also gains knowledge and experience useful for our operations in space. This intelligence, vital to the United States for future defense and peaceful pursuits, can be greatly expanded through advanced Orbital Systems developed by **CONVAIR-Astronautics** from its experience with the Atlas.

**space/aeronautics**